UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

October 15, 2003–

OFFICE OF
THE ADMINISTRATOR
EPA SCIENCE ADVISORY BOARD

Note to the Reader:

The attached draft report of the Advisory Council on Clean Air Compliance Analysis Special Council Panel for the Review of the Third 812 Analysis (COUNCIL) is still undergoing discussion and review. Once discussed by the COUNCIL at a public session, and after approval, it will be transmitted to the EPA Administrator and become available to the interested public as a final report.

This draft has been released for general information to members of the interested public and to EPA staff. The reader should remember that this is an unapproved working draft and that the document should not be used to represent official EPA or Council views or advice. Draft documents at this stage of the process often undergo significant revisions before the final version is approved and published.

The SAB is not soliciting comments on the advice contained herein. However, as a courtesy to the EPA Program Office that is the subject of the review, we have asked the Program Office to respond to the issues listed below. Consistent with SAB policy on this matter, the Council is not obligated to address any responses it receives.

1. Has the Committee adequately responded to the questions posed in the Charge?
2. Are any statements or responses made in the draft unclear?
3. Are there any technical errors?

For further information or to respond to the questions above, please contact:

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United States Environmental Protection Agency | EPA Science Advisory Board (1400A) Washington DC | EPA-SAB-COUNCIL-ADV-XXX-XX [date] *www.epa.gov/sab*

Interim Installment: REVIEW OF THE REVISED ANALYTICAL PLAN FOR EPA'S SECOND PROSPECTIVE ANALYSIS - BENEFITS AND COSTS OF THE CLEAN AIR ACT 1990-2020

An Advisory by a Special Panel of the Advisory Council on Clean Air Compliance Analysis

[Date]

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

EPA-SAB-COUNCIL-ADV-01-004

Marianne Horinko
Acting Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Subject: Review of the Draft Analytical Plan for EPA's Second Prospective Analysis - Benefits and Costs of the Clean Air Act, 1990-2020: An Advisory by the Advisory Council for Clean Air Compliance Analysis

Dear Adminstrator Horinko:

The US EPA Science Advisory Board's Advisory Council for Clean Air Compliance Analysis Special Panel (the Council) presents in this document a first installment on its review of the Draft Analytical Plan for EPA's Second Prospective Analysis - Benefits and Costs of the Clean Air Act, 1990-2020. While this review would ordinarily have been complete in a single document, we have elected to provide a phased review because portions of the Draft Analytical Plan were recalled by the Agency for revision after our review process had begun in May of 2003. In order to provide what advice we could on the unaffected portions of the Analytical Plan, the Council elected to move forward with the review process for some of the Charge Questions.

The Council's deliberations to date have focused on Charge Questions concerning Scenario Development (CQ 2), Alternative Pathways (CQ 3), Cost Estimates (CQ 7), Computable General Equilibrium Modeling (CQ 8), Discounting (CQ 9), Data Quality and Intermediate Data (CQ 32), and Results Aggregation and Reporting (CQ 33). Advice on these topics was either of relatively greater urgency for the Agency, or relatively unaffected by the partial recall. Similarly, the Council has discussed the report of its Air Quality Modeling Subcommittee on emissions and the Health Effects Subcommittee on the Agency's proposed approach to analyzing health effect impacts of implementing the CAA.

The Executive Summary of this Interim Installment itemizes in point form the main issues of concern to the Council. In this cover letter, we elect to emphasize just three key points:

(a.) The Council endorses enthusiastically the Agency's new strategy of seeking advice during the planning stages of an exercise as complex and comprehensive as the Second Prospective Analysis. Early intervention, and therefore the opportunity to influence the Agency's approach to this important project, is far more valuable than merely an ex post opportunity to criticize what was done.

(b.) The Agency's analysis is a massive undertaking, and even the 450 page Draft Analytical Plan is insufficient, in many cases, to reveal the exact methods that the Agency proposes to use. Official feedback from the Agency on initial drafts of our advice has been very helpful. However, the Council's advice could be better, and more timely, if more detail could be provided about many aspects of the planned analysis.

(c.) It is essential for the Agency to understand the "general equilibrium" consequences of CAAA regulations. Controls placed on one sector can spill over into other sectors and other regions through their effects on prices in markets for goods, labor, and capital. The Council stresses the importance of high-quality Computable General Equilibrium (CGE) models in the Agency's toolkit for the Second Prospective Analysis.

We appreciate the opportunity to review the Analytical Plan and to provide you with advice on the design of the Agency's approach so that the resulting study would have the most validity and utility for the Agency and Congress. The Council would be pleased to expand on any of the findings described in this report and we look forward to your response.

Sincerely,

Dr. Trudy Ann Cameron, Chair
Advisory Council on
Clean Air Compliance Analysis

NOTICE

This report has been written as part of the activities of the EPA Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use.

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1 EXECUTIVE SUMMARY

Throughout this first installment of the Council Special Panel's review, key points are summarized in bullet form at the end of each discussion. These key points are collected here, organized by each main topic. The Agency should be aware that these points do not necessarily constitute the Panel's last word, since we may revisit some of this material in our face-to-face meeting. These interim comments are offered in the interest of making timely advice available to the Agency.

Project Goals and Analytical Sequence [TO BE DEFERRED UNTIL FINAL INSTALLMENT?]

- Disaggregation is a very desirable strategy which should be pursued to the extent that analytical resources permit, subject to the constraints imposed by nonlinearities and general equilibrium effects.
- Air toxics remain an important issue in the 812 Analysis. The benzene case study is a good start, but much more work is still necessary. Case studies are merely a beginning.
- Human health risk reductions may be the most substantial benefit from the CAAA, but they are not the only important benefit. Benefits to ecosystems and other welfare benefits such as visibility are likely to be substantial and are still receiving limited attention. The Council recognizes substantial challenges in quantitative assessment of these benefits and will discuss these more in the next installment of this advisory.
- Chapter 1 of the 812 study should address the pervasiveness of uncertainty in cost and benefit estimates, but then identify the methods EPA will use to identify the most important areas of uncertainty. Those elements that are both highly uncertain and have a significant impact on the results should be the focus of sensitivity analyses. Sensitivity/uncertainty analysis needs to be an iterative process to identify and assess the significance of key uncertainties in each step of the assessment. Only a selected set of the most influential uncertainties should be quantitatively followed all the way through to the final results.

Scenario Development

- The evolving baseline assumptions for the 812 Analysis need to be carefully benchmarked against realized values of key forecasts from previous editions of the analysis, and sensitivity analysis with respect to key assumptions will be important.
- Care must be taken to ensure that key assumptions affecting different components of the overall 812 Analysis (discount rates, income growth projections, substitutability) are consistent across all the models used in the analysis.
- The "with CAAA" and "without CAAA" scenarios are neither observable nor likely to materialize exactly as described. They are artificial constructs. However, they should at least be internally consistent. The agency should make it

very clear to the audience for the 812 Analysis whether the post-2000 benefits of the CAAA are expected to stem from the prevention of deterioration in air quality, rather than absolute improvements.

- The evolutionary nature of regulations pursuant to the CAAA means that is difficult to forecast future benefits and costs based solely on knowledge of the shape of current regulations. EPA needs to be clearer about how feedback and regulatory evolution will be modeled.

Alternative Pathways [TO BE DEFERRED UNTIL FINAL INSTALLMENT? YES/NO]

- The "alternative pathways" analyses are somewhat problematic. Unless some analysis of compound changes is specifically required of the Agency, or some specific policy proposal must be considered, it would be preferable to focus instead on exploring the separate marginal effects of shifting abatement responsibility between sectors, one at a time.
- It is not possible to hold benefits constant across alternative pathways so that costs can be simply compared. Even if aggregate emissions are held constant, there are likely to be substantial differences in health and non-health benefits across regions.
- If the Agency is obliged to provide some analysis of "alternative pathways" despite the Council's reservations about this exercise, the analysis should accommodate the regional consequences--in particular, the constraints implied by the NAAQS on regional ambient concentrations of pollutants. The criterion that aggregate emissions be held constant across different control strategies will be unlikely to satisfy the NAAQS.
- If "alternative pathways" are pursued, the same general equilibrium considerations attendant to the main scenario analyses will need to be acknowledged.

Cost Estimates

- Econometric models for abatement costs are limited by their incomplete coverage but they can sometimes offer insights not available from engineering estimates of compliance costs, in particular, with respect to the impacts of abatement activity on total factor productivity. Econometric models are one important source of the stylized facts about economic relationships that are used to calibrate CGE models.
- Indirect costs should be defined and itemized more clearly in the Analytical Plan.
- Comparison of the predicted and actual costs of air quality regulations will be important to the evolution of the ongoing Section 812 Analyses.
- Assumptions about the effect of learning on abatement costs need to be carefully thought-out and supported by the literature in this area. It is not clear that the "80% rule" is valid or even that it is an appropriate place-holder in the analysis. Learning effects are likely to be heterogeneous across sectors and processes and no consensus on their magnitude has yet emerged.

- The IPM exhibits a number of limitations for cost modeling (its lack of coverage, lack of regionality, assumptions of efficient pricing and possibly its assumptions about the initial allocation of emission allowances). All of these problems will need to be addressed carefully.
- Future conditions in energy markets may have strong implications for realized abatement costs. Sensitivity of the benefit-cost results to alternative assumptions about energy markets may be an important dimension of the 812 Analysis. Other concerns with respect to abatement costs include some caveats about comparisons with the Pollution Abatement Cost and Expenditures (PACE) Survey data, the need for consistency in discounting assumptions, some questions about the use of ControlNet, the NAAQS and PACE data, and the relative cost of abatement via market-based instruments versus command and control.

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Computable General Equilibrium Modeling

- Incorporation of spillover costs of air quality regulations is important and these costs should continue to receive close attention.
- CGE models have the capability to reveal spillovers of air quality regulations into unregulated sectors, not just to better estimate the direct costs of regulation on regulated sectors. The current Analytical Plan describes CGE methods only for "post-processing" and relegates them to secondary status. General equilibrium modeling should enjoy similar status to direct cost calculations.
- Each of the main CGE models which are proposed for use in the 812 Analysis has some limitations. The JHW model has a longer track record and has been more extensively reviewed. The zero-substitutability assumption apparently made in the AMIGA model represents a major cause for concern to the Council.
- The Council advocates a serious effort to accommodate the consequences of possible tax interactions in the 812 Analysis. Considerable sensitivity analysis is indicated, however, since simple formulas for the magnitudes of tax interactions for regulations imposed on particular sectors have not yet been identified.
- CGE models and econometric models for costs are not competing methods, but complementary methods. Econometric results, where available and appropriate, are generally more desirable than expert judgment for calibrating the parameters of CGE models. However, where no econometric estimates exist for key parameters, expert judgment is essential.

Discounting

- The discounting of future benefits and costs by individuals is a complex cognitive process and the literature on discounting is replete with empirical anomalies. Economic theory provides a framework for thinking about the appropriate common discount rate to use in discounting aggregate future net social benefits. However, exactly what social discount rate is the "right" single common rate is remains subjective and a matter of debate. Time preferences in a population depend upon the particular choice context, which includes factors as

diverse as the time horizon, the sizes of the benefits and costs, and the distribution of subjective life expectancies in the affected population. The 812 Analysis should conform to the recommended treatment of discounting spelled out in the EPA's Guidelines for Benefit-Cost Analysis. Deviations from this advice are admissible, of course, but they should be explained and justified by more-recent research.

- The reported results of the Agency's benefit-cost analysis should make clear the extent to which uncertainty about the bottom line depends upon assumptions about the appropriate social discount rate.
- Wherever the 812 Analysis must accommodate non-contemporaneous benefits and costs, the discount rate that is used should be consistent. Exceptions should be justified by large differences in the time horizons involved or perhaps large differences in the ages of the affected populations, supported by empirical results to back up any assumed differences.

2 INTRODUCTION

2.1 Background

The purpose of this Advisory is to continue the Council's advice to the Agency in developing the third in a series of statutorily mandated comprehensive analyses of the total costs and total benefits of programs implemented pursuant to the CAA. Section 812 of the Clean Air Act Amendments (CAA) of 1990 requires the EPA periodically to assess the effects of the 1990 CAA on the "public health, economy and the environment of the United States" and to report the findings and results of the assessments to Congress. Section 812 also established the Council and gave it the following mission: "to review the data and methodology used to develop the 812 Study and to advise the EPA Administrator concerning the utility and relevance of the Study." EPA has, to date, completed two assessments and received the advice of the Council on them: *The Benefits and Costs of the Clean Air Act: 1970 to 1990* (published 1997) and *The Benefits and Costs of the Clean Air Act, 1990 to 2010* (published 1999).

In this document, a special panel of the Council provides an initial installment of its review or the May 12, 2003 *Analytical Plan* for the study, and revisions to that plan dated July 8, 2003. The *Analytical Plan* is more formally titled *Benefits and Costs of the Clean Air Act 1990-2020: Revised Analytical Plan for EPA's Second Prospective Analysis*. It reflects earlier advice that the Council provided in September 2001 in its earlier Advisory concerning a draft version of the *Analytical Plan* (EPA-SAB-COUNCIL-ADV-01-004).

In the course of the review of this revised document, the Council will review the Agency's major goals, objectives, methodologies, and analytical choices for the Section 812 Study before it is implemented. In its review of the analytical plan, the Council and its panel and subcommittees are guided by the charge questions as identified in the CAA of 1990,[1]

a) Are the input data used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?
b) Are the models, and the methodologies they employ, used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?
c) If the answer to either of the two questions above is negative, what specific alternative assumptions, data or methodologies does the Council recommend the Agency consider using for the second prospective analysis?

[1] Specifically, subsection (g) of CAA §312 (as amended by §812 of the amendments) states: "*(g) The Council shall -- (1) review the data to be used for any analysis required under this section and make recommendations to the Administrator on the use of such data, (2) review the methodology used to analyze such data and make recommendations to the Administrator on the use of such methodology; and (3) prior to issuance of a report required under subsection (d) or (e), review the findings of such report, and make recommendations to the Administrator concerning the validity and utility of such findings.*"

The Agency provided the Council with additional detailed charge questions for its consideration. These detailed charge questions were initially provided to the Council in May 2003 and then revised and resubmitted in July. The final set of 37 charge questions is included in Appendix A.

2.2 Process for Developing this Advisory

To address the charge questions identified by the Agency regarding the Analytical Plan, the SAB Staff Office, with the advice of the Council Chair, formed a Special Council Panel for the Review of the Third 812 Analysis to provide the Council with additional expertise in the areas of expert elicitation, uncertainty analysis and statistical and subjective probability. The Staff Office also issued a call for new membership on the Council's Air Quality Modeling Subcommittee (AQMS) and its Health Effects Subcommittee (HES).

The Council Special Panel held a public teleconference on May 28, 2003 to plan its approach for providing advice. Those members participating in the teleconference voted to cancel a planned face-to-face meeting during June 11-13, 2003, pending more information about those portions of the Analytical Plan that were to be revised. The majority of these revisions were completed and submitted to the council on July 8. The Council held one teleconference on July 11 and another on July 15, where a subset of the charge questions considered most urgent by the Agency were addressed. Those charge questions were 1, 2, 3, 7, 8, and 9. Teleconferences on September 23 and September 24 continued this discussion and also addressed charge questions 32 and 33. Discussion of question 1 (Project Goals and Analytical Sequence) and question 3 (Alternative Pathways) raised the need for additional information from the Agency, so this Advisory does not include the Council's last word on these topics. The remaining questions of these initial eight are addressed in this Interim Installment of the Council's Advisory.

In addition to the advice provided in this document, the Council's AQMS has met to address issues concerning the Agency's plans for estimating emissions and the HES has met to address the Agency's plan to assess health effects. The advice developed by these Council Subcommittees will be provided in separate reports.

3 PROJECT GOALS AND ANALYTICAL SEQUENCE

[TAC: Shall we defer this section entirely to the final installment, or report our interim advice?]

In its first two substantive teleconferences, the Council did not discuss the Analytical Plan in its entirety. The Council's initial discussion of a number of points will be summarized in this document, so that this advice can be provided in a timely fashion. The Council does not anticipate any changes to the specific points made here, but additional points may emerge as the remainder of the Analytical Plan is discussed in detail.

3.1 Charge Question 1

Does the Council support the study goals, general analytical framework, disaggregation plan, analytical sequence, and general analytical refinements defined in chapter 1? If there are particular elements of these plans which the Council does not support, are there alternatives the Council recommends?

3.2 Disaggregation

The Council applauds the Agency's willingness to disaggregate, something that the Council has recommended for some time. In an ideal world, the disaggregation would be at the level of individual regulatory decisions so that the Agency, Congress, and society would know whether each regulation should be tightened or loosened. Effort toward disaggregation to the level of individual sectors is an important step.The next steps beyond sectoral disaggregation might be limited regulation-by-regulation disaggregation and/or some cautious region-by-region disaggregation (although this is likely to be more feasible for selected benefits than for costs)

There remain some important constraints on the task of disaggregation. The Council understands that it is often impossible to separate the benefits or costs of abating one pollutant versus another. Analytical resource constraints must also be accommodated. The Council also warns that the benefits and/or the costs associated with different sectors, regulations, or regions may not be additively separable because of nonlinearity or interaction effects among the disaggregated entities. In addition, general-equilibrium adjustments may shift incidence among sectors and regions. These complications make the process of disaggregating benefits and costs more difficult. However, decision makers often are interested in sectoral and regional effects. Providing disaggregated estimates wherever possible will increase the usefulness of the analysis in policy making.

- **Disaggregation is a very desirable strategy which should be pursued to the extent that analytical resources permit, subject to the constraints imposed by nonlinearities and general equilibrium effects.**

3.3 Air Toxics

MACT requirements. The planned attempt to address the particular benefits and costs of abating toxics is a step forward and the Council applauds the Agency for this effort. While the proposed case study on benzene will be very helpful, however, the effort should not be expected to stop there. For example, Congress mandated maximum achievable control technology (MACT) for a list of chemicals, but the chemicals on this list were not identified by any rigorous systematic analysis. This mandate has imposed substantial costs on the economy without any formal assessment of either its benefits or its costs.

We are about to enter the era when the Agency must examine the residual risk after MACT to determine whether more stringent regulations are required in some cases. One role of the Section 812 analyses is to explore new methods relevant to the assessment of environmental management strategies. This is a good reason for the Second Prospective Analysis to address the task of benefit-cost analysis with respect to the control of air toxics. The Agency is likely to find that MACT is justified for some chemicals and unjustified for others. These insights will be important to the Administrator, to Congress, and to society more generally.

Case studies. The benzene study was recommended in the last round of Council advice primarily because of the relatively greater availability of data on this HAP. It would be useful to have the Agency propose some other target examples for case studies. Whether these can actually be pursued in the context of the Second Prospective Report is questionable, but assessment of hazardous air pollutants (HAPs) should be a priority among longer-term assessment tasks facing the Agency. Perhaps additional resources could be made available for this "sidebar" enterprise that will have to take place contemporaneously with the Section 812 evaluation.

As a starting point for future analyses, perhaps the Agency should pick at least one chemical that is likely to have regulatory benefits exceed costs, and at least one chemical that will have costs exceed benefits. This would constitute a useful demonstration exercise that could reveal what resources are required for this type of air toxics analysis. Alternatively, some argument can be made that it would be preferable to see a more representative sample of HAPs being analyzed, for example, those from relatively small sources, such as perchlorethylene from dry cleaning establishments, or chromate from plating operations. These tend to be from isolated sources, rather than major sectors, and to be common in urban areas.

Are case studies really useful in the formal benefit-cost analysis of the Section 812 study? Perhaps not directly, but the Council advocates these exercises as part of "progress toward a goal," rather than suggesting that they represent any intermediate or final input to the current benefit-cost analysis. More-complete and more-formal analysis of air toxics is certainly needed as the Section 812 analytical process matures. As in the case of certain aspects of the calculation of non-market economic benefits, the air toxics tasks fall into the category of methods development, or contributions to the evolution of a body of knowledge—efforts that are relevant to the ongoing Section 812 analytical activity. Fostering valuable new research is a tangential goal of the 812 process.

- **Air toxics remain an important issue in the 812 Analysis. The benzene case study is a good start, but much more work is still necessary. Case studies are merely a beginning.**

3.4 Non-health benefits

Mortality risk reduction benefits are about 90% of total benefits in the previous Section 812 analyses. But it is likely to be implausible to most people (and most members of Congress) that non-mortality health benefits are small, or that benefits other than human health benefits are tiny or immeasurable. The Analytical Plan touches on visibility as a non-health effect. More contentious, and probably more important, are the benefits from protection of the natural environment (ecosystems) stemming from the Clean Air Act Amendments (CAAA).

In the first round of advice from the Council to the Agency concerning the Second Prospective Analysis (EPA-SAB-COUNCIL-ADV-01-004), the Council emphasized that the Costanza et al. (1998) method was an inappropriate way to approach the task of ecosystem benefits estimation. However, the Agency cannot ignore this category of benefits or continue simply to characterize their valuation as intractable. Certainly the planned case study is too little. Delays in bringing online the SAB Committee on Valuing the Protection of Ecological Systems and Services and a new subcommittee of the Council, the Ecological Effects Subcommittee, may lead to corresponding delays in any advice that can be provided to the Agency concerning the challenges presented by valuation needs in this area. Nevertheless, the insights from the Special Panel's deliberations will be very important to the 812 process.

Visibility. Benefits from the improvement of visibility in the Second Prospective Analysis are limited to recreational visibility benefits. The Agency indicated that the main residential visibility study at its disposal had been judged to be too old to use. In fact, there is additional research that is more recent (e.g. Beron, Murdoch and Thayer, 2001). As much as any other category, visibility benefits have figured large in empirical air quality benefits estimates from hedonic property value models. The goal in approaching visibility benefits should be to focus on filling the data gaps that exist. Additional effort on this front can help reduce errors in benefits calculations stemming from omitted categories of benefits.

It is possible, independent of the Beron, Murdoch and Thayer (2001) paper, to consider evaluating stated preference studies concerning residential visibility. It is not clear whether any careful review has been conducted to evaluate whether the observed variations in estimates are due to study design features, local conditions, or other factors. The recreational visibility studies are also rather old, dating back to 1990. EPRI is sponsoring a study conducted by Dr. Anne Smith of Charles River Associates. The Agency should contact this research team to determine the status of its work.

Morbidity. Morbidity effects are discussed in the Health chapter, but are not sufficiently pervasive throughout the rest of the Blueprint. It appears from the Analytical Plan that the Agency will downplay morbidity reductions in summarizing the analysis of CAAA benefits. Certainly, the Agency proposes to address a number of morbidity issues, but it would be desirable to see a more thorough integration of morbidity effects, not just mortality effects, whenever benefits are addressed in the document.

The Council notes that mortality risk-reduction estimates may dominate benefits estimates if they are not measured correctly. WTP may be lower than is often estimated in wage and stated preference studies if some mortality benefits consist of life extensions at the end of life with compromised function or other forms of co-morbidity.

- **Human health risk reductions may be the most substantial benefit from the CAAA, but they are not the only important benefit. Benefits to ecosystems and other welfare benefits such as visibility are likely to be substantial and are still receiving limited attention. The Council recognizes substantial challenges in quantitative assessment of these benefits and will discuss these more in the next installment of this advisory.**

3.5 Uncertainty

Uncertainty will be addressed much more comprehensively in the Council's discussion of Chapter 9 of the Analytical Plan. However, with respect to the overview of the Agency's goals in Chapter 1, it would be helpful to see more attention to the pervasiveness of the problem of uncertainty, especially where linearity assumptions are crucial and tenuous. Uncertainty analysis is something that needs to be ongoing throughout the assessment process. Informed judgments need to be made about what might be the key sources of uncertainty, and the potential consequences of this uncertainty, in each step of the assessment.

However, this does not mean that every alternative model and alternative assumption needs to be tracked all the way through the assessment to the bottom line. The Council does not wish to lead the Agency down an intractable path of including so many alternative models and alternative assumptions that the assessment loses its focus and coherence. For example, it is vitally important that the electric utility cost analysts

do some assessment of how sensitive the cost results are to different assumptions about the future price of natural gas on general economic growth, and some discussion of this exploration should be reported in the Second Prospective Analysis. However, only those elements that are both highly uncertain and have a significant impact on the results need to remain at center stage throughout the formal uncertainty analysis.

- **Chapter 1 of the 812 study should address the pervasiveness of uncertainty in cost and benefit estimates, but then identify the methods EPA will use to identify the most important areas of uncertainty. Those elements that are both highly uncertain and have a significant impact on the results should be the focus of sensitivity analyses. Sensitivity/uncertainty analysis needs to be an iterative process to identify and assess the significance of key uncertainties in each step of the assessment. Only a selected set of the most influential uncertainties should be quantitatively followed all the way through to the final results.**

4 SCENARIO DEVELOPMENT

4.1 Charge Question 2

Does the Council support the choices for analytical scenarios defined in Chapter 2? Are there alternative or additional scenarios the Council recommends EPA consider for inclusion in the analysis?

4.2 Benchmarking and sensitivity analysis

First, the Council recommends changing the description of the different scenarios from "pre-CAAA and post-CAAA" to "with CAAA and without CAAA." This simple change will eliminate confusion between differences over time and counterfactual differences over alternative scenarios, which is the intended distinction.

To evaluate the implications of the proposed update of the 1990 Baseline Emissions assumptions, it would be helpful to have an explicit comparison of how the proposed update to the 1990 baseline differs from the earlier 1990 baseline. The Second Prospective Report should compare the ambient pollution concentrations implied by the 1990 baseline used in the First Prospective Report versus the new baseline, and each ambient concentration should be compared with the 1990 actual monitored values for each pollutant. This could be done for targeted metropolitan areas (e.g., the Los Angeles air basin).

The description in the First Prospective Report suggests that a scaling factor was used to adjust the projected ambient quality in 2000, and 2010. This scaling factor was

apparently derived by taking the ratio of modeled target year to modeled base year, and applying this ratio to scale base year concentrations (whether monitored directly or estimated using e-VNA) to get the projected target year concentration. This type of benchmarking, of backcasted simulations to actual observed outcomes in 1990 and 2000, should be possible in the Second Prospective Analysis. It would help policy-makers understand the sensitivity of the results from air quality models to changes in the emissions profiles used in the analysis.

- **The evolving baseline assumptions for the 812 Analysis need to be carefully benchmarked against realized values of key forecasts from previous editions of the analysis, and sensitivity analysis with respect to key assumptions will be important.**

4.3 Consistency: economic activity and incomes

At the time the analysis was done for the First Prospective Report, our expectations for economic activity were completely different than the realities experienced between 1999 and 2003. There is no discussion of how the recent slowdown in economic activity is being incorporated into the projections for 2000, 2010, and 2020. *There must be some discussion of this linkage*. A component of the uncertainty analysis will have to consider the status of the aggregate economy, including any assumptions about when there may be a return to a more robust growth pattern. Otherwise, the exercise might seem foolish.

There should be some explicit discussion of the connections between assumptions about economic activity at aggregate level and the corresponding assumptions about household income growth that underlie the benefit measures. These assumptions should be consistent throughout the analysis. The Agency needs to make its "central case" economic assumptions perfectly clear, although the Council notes that there will continue to be considerable uncertainty about the nature of the relationship between economic activity and emission rates. Even a well-defined central case assumption about future levels of economic activity will not lead to an unambiguous forecast about pollutant emissions.

There is a need for sensitivity analysis concerning any assumptions about the baseline level of overall macroeconomic growth. However, the need to understand uncertainty about baseline growth rates for the economy as a whole is distinct from the need to understand the uncertainty about any differences in growth rates across individual sectors of the economy. It is possible that assessments of the behavior of particular sectors are excessively dependent upon the predictions of just a small set of models. These models are, in general, rather highly aggregated and have been developed for different purposes than those for which they are being used in the Second Prospective analysis. The Agency should use alternative models and solicit expert judgment on these issues, perhaps via a workshop. Rather than starting with the predictions of these models,

it is important to step back and evaluate each model's assumptions and the sensitivity of its predictions to these assumptions.

Consistency is also an important issue in several other places in the Analytical Plan. For example, there is some discussion of meta-analysis with respect to the value of a statistical life to be used in the analysis. In the context of this discussion, there is mention of the prospect of making adjustments to VSL estimates to account for differences in income levels. How do these proposed income adjustments correspond to the income changes that are part of the general equilibrium consequences of the effects of air quality regulations on costs of production and therefore upon factor demands?

Finally, the underlying assumptions of different types of models used in the Analysis must be compatible. Most procedures for benefits assessment based on revealed preferences of individuals hinge crucially upon non-separability between pollution levels and observable behaviors. It is highly inconsistent to *require* non-separability in support of the valuation portion of the analysis that supports the benefits estimates, yet to *preclude* it in the general equilibrium assessment of cost estimates. How are the insights from Williams (2002, 2003) concerning health effects and optimal environmental policy to be incorporated as adjustments? Will there be scenarios to test the sensitivity of the cost estimates to these adjustments?

- **Care must be taken to ensure that key assumptions affecting different components of the overall 812 Analysis (discount rates, income growth projections, substitutability) are consistent across all the models used in the analysis.**

4.4 Artificiality of scenarios

In the First Prospective Report, none of the emissions scenarios are "real" in the sense of being based on actual conditions or even a forecast of actual conditions. The baseline "without CAAA" scenario has not been observed and neither will the "with CAAA" scenario actually materialize. For example, many non-attainment areas will remain out of attainment. It is also difficult to fully anticipate all of the general equilibrium consequences of the CAAA regulations. Both the Baseline and the Control are based on hypothetical scenarios defined to meet the specific mandates of the CAAA. Neither the baseline nor the control scenarios would be interpreted as a necessarily credible forecast of real conditions. As a result it is not clear, from the description of the different scenarios, how a couple of important issues are to be addressed:

1. If firms are currently minimizing costs, increased emission controls imply higher costs and, under the assumptions of most CGE models, higher prices. These price increases will change the distribution of economic activities by sector and the resulting levels of emissions from each sector. How are these general equilibrium consequences of emissions controls to be handled? Shouldn't there be comparisons that allow uncertainties in aggregate economic activity and technical

change to be described, especially as one attempts to forecast activity levels and emissions further into the future (e.g., beyond 2010)?

2. What is the nature of the feedback loop to measure changes in household incomes in response to these policies? At a minimum, one should be able to deal with Hazilla-Kopp, Jorgenson-Wilcoxen type computations of the effects of policy on their measures of costs. The price vectors derived from these models include wages and returns to capital, so it should be possible to evaluate the implied changes in household incomes. This type of interconnectedness is very relevant to the process of scenario development. It is not clear in the Analytical Plan whether there are inconsistencies across components in the different assumptions about how economic activity affects the outcomes.

- **The "with CAAA" and "without CAAA" scenarios are neither observable nor likely to materialize exactly as described. They are artificial constructs. However, they should at least be internally consistent.**

4.5 Trajectories after 2000: preventing deterioration

The Council now understands that the shapes of the time profiles in Exhibit 2-1 are not factual, and that the diagram is merely a schematic designed to identify the different reference periods. However, the "without-CAAA" and "with-CAAA" trajectories in this diagram, if used, suggest to readers that with the CAAA, emissions decline from 1990 to 2000, but then remain fairly flat. For 2010 and 2020, the benefits of the CAAA result entirely from how high emissions would have risen without it. These trajectories may be plausible, but it will be important to communicate to policy makers that the large benefits that the Second Prospective analysis is likely to identify for 2010 and 2020 stem from the prevention of air quality deterioration that would otherwise have occurred. Emissions are not expected actually to decrease in absolute terms after 2000 as a result of the 1990 CAAA. They will only decrease relative to what they would otherwise have been.

- **The agency should make it very clear to the audience for the 812 Analysis that the post-2000 benefits of the CAAA are expected to stem from the prevention of deterioration in air quality, not absolute improvements.**

4.6 The moving target problem

The inventory of new regulations and changes since the first prospective study (pages 2-9 and 2-10) highlights the fact that the Clean Air Act was designed to be an evolving regulatory process (e.g., with periodic reviews of the NAAQS). This adaptive evolution allows for adjustments and/or additions to the arsenal of regulations and emission control strategies in response to new scientific or engineering knowledge and technological innovations.

Some previous regulations have precipitated technological innovations (e.g. as with automobile emission controls) that have allowed the achievement of greater emissions reductions, at lower costs, than were originally expected. At the same time, most standards have been held the same or tightened due to new information that some of the human health and environmental effects of air pollution are worse than originally thought. All this means that assessing the future costs and benefits of the CAAA is like trying to hit a moving target. There is no remedy for this, but it remains a limitation of the entire assessment exercise that should be emphasized to policy-makers.

The National Ambient Air Quality Standards (NAAQS) are a complication in forecasting scenarios for the Section 812 Analysis. Are the emission controls currently in place and those expected to come on line in the future, under the CAAA, going to be sufficient to meet the NAAQS? If not, then more emissions limits or control requirements will presumably have to be implemented. These modifications will be driven (or constrained) by NAAQS attainment schedules and SIP schedules.

The discussion on page 1-3 of the Analytical Plan seems to imply that there will be some mechanism in the analytical process to periodically assess progress toward meeting the NAAQS under a particular scenario. If the growth in emissions is larger than anticipated, this assessment could potentially trigger feedback in the form of additional emissions reductions requirements (with their associated costs and benefits). However, it is not as clear in Chapter 2 of the Analytical Plan that this feedback will be incorporated.

One of the most important scenarios may be the "additional controls" scenario (i.e. going beyond current CAAA requirements). This scenario is likely to be more relevant than the alternative pathways scenarios suggested in the current Plan. It is listed as a scenario in the current Plan, but little detail is provided (Chapter 2). This scenario seems important because it may stimulate discussion about what the alternatives may be for different emissions source categories, and may suggest least-cost directions for future policy.

- **The evolutionary nature of regulations pursuant to the CAAA means that is difficult to forecast future benefits and costs based solely on knowledge of the shape of current regulations. EPA needs to be clearer about how feedback and regulatory evolution will be modeled.**

4.7 Inspection and Maintenance (I/M) Programs

The alternate pathways scenarios as outlined in Chapter 2 of the Analytical Plan include enhanced I/M programs as a major control in smaller urban areas around the country. If these areas are already in attainment of air quality standards, this will result in very little benefit in terms of attainment, although nationwide emissions will

fall. However, the Agency assume no threshold in health effects from particulate matter, so there may still be benefits in terms of improved health outcomes.

Also, modifications to the MOBILE model in version 6 reflect the fact that post-2000 vehicles are very clean and much more likely to stay clean over their lifetimes, resulting in small emissions reductions from enhanced I/M, at least for light duty vehicles (heavy duty vehicles are not currently tested in most regions, and some type of monitoring of their compliance might be more interesting).

It would seem important in this scenario to look at additional reductions from mobile sources in non-attainment areas that are likely to result in additional emissions reductions. The Council believes that EPA should consider other policies, as is suggested on Page 2-15. A set of alternative mobile source reduction strategies (costs and emissions reductions) is also an important part of looking at the costs of meeting the NAAQS.

5 ALTERNATIVE PATHWAYS

[SHALL WE DEFER THIS SECTION UNTIL THE NEXT INSTALLMENT? The September 23rd teleconference included a request that the Agency develop some additional information for the Council on the details of the Alternative Pathways analysis for the November face-to-face meeting.]

5.1 Charge Question 3

Does the Council support the alternative compliance pathway estimation and comparison methodology described in chapter 2, including the specification of alternative compliance pathways which may not reflect precisely constant emissions or air quality outcomes between scenarios due (primarily) to the non-continuous nature and interaction effects of emission control options?

5.2 Justification for changes in the menu

The original Analytical Plan described in the May 12, 2003 document contained a different menu of alternative pathways than the revised document of July 8, 2003. The Council feels that this raises questions about why the Agency decided to make a dramatic change in Alternative Pathway 2 on page 2-14. Was this a consequence of changes in the New Source Program, allowing old coal fired plants to stay on line with some upgrades but no requirement for meeting New Source Review process? From the viewpoint of the Agency, what makes the alternative pathways outlined in the revised document preferable to the alternative pathways outlined in the original document?

5.3 What is the goal in studying alternative pathways?

Three types of "with CAAA" scenarios are discussed in the Analytical Plan:

1. "sector-specific" scenarios in which CAAA regulations are removed from one sector at a time,
2. "supplemental" scenarios which include additional regulatory controls on utilities and/or mobile sources, and
3. "alternative pathway" scenarios in which increased regulations on utilities and/or mobile sources are complemented by relaxed restrictions on other sectors in a manner that produces similar emissions (a proxy for constant health and environmental effects) as the base "with CAAA" scenario.

The Council agrees that the “sector-specific” and “supplemental” scenarios are useful because they provide some information about the incremental costs of relaxing or tightening restrictions on particular sectors which should be useful for policy design. However, the Council is concerned that the proposed “alternative pathways” may prove

less useful because they involve simultaneous changes to multiple sectors. To reveal more about sensible directions in which regulations should be adjusted, the Agency should consider scenarios that consist of removing controls from one sector at a time, then separately imposing them instead on another sector, rather than implementing both changes at once.

In plain language, the Agency needs to figure out how to increase benefits and reduce costs within a set of control strategies that are feasible technically, and maybe economically and politically. If the Agency determines that one sector--for example electric utilities (i.e., coal-burning power plants), transportation (diesel engines, or gasoline engines, etc.), or some other sector--is responsible for a large portion of negative health effects and that controls on that sector can be implemented with costs much less than the health benefits to be obtained, then the Agency ought to regulate that sector more stringently and others less stringently.

It would have been helpful if the Analytical Plan had been more articulate about what the Agency is trying to accomplish with the alternative pathway analyses. These exercises may actually respond to a mandate for comparison of the overall net benefits of the current policy against some discrete alternative policies that would achieve the same goals. From an economic perspective, however, the optimality of a particular policy rests on marginal costs and marginal benefits. It is difficult to develop an understanding of marginal costs and marginal benefits when more than one change is made at the same time. It should not be surprising that costs skyrocket if one loads all of the abatement requirements onto one sector in a discrete shift. It would be desirable to get at these alternatives in a way that would be more useful for policy.

Compound scenarios will be more difficult to describe and so there is a greater chance that they will lead to misunderstandings by users of the report. When restrictions are tightened on one sector, the benefits and costs may be sensitive to the many details of how restrictions are relaxed on other sectors, which would also be difficult to adequately report. If compound scenarios are to be pursued, the Agency will have to proceed with great caution in explaining the complexities involved in substituting one type of regulation for another.

If alternative pathways are pursued, the Council recommends including only scenarios that differ from the base "with CAAA" scenario in comparatively simple and easily described ways. These analyses could easily become overly complex. It would be preferable to examine sector-specific scenarios. The effects of compound policy changes that simultaneously increase regulations on some sectors and relax restrictions on others may be approximated by combining the incremental effects of the separate increases and decreases.

If particular compound combinations of changes are of explicit policy interest, these can of course be analyzed directly as part of a policy proposal, but it is not clear whether any such specific policy proposal should be pursued in the main 812 Analysis. For example, it may be relevant to explore possible future particulate matter (PM)

regulatory strategies aimed at coal-burning power plants, diesel engines, or other specific types of PM sources. These strategies could be motivated by emerging knowledge about the health impacts of PM composition and particle size, suggesting that controls on some types of sources may provide more health benefits than controls on other PM sources (on a per-unit-of-emissions basis).

If no particular future policy is being assessed, it may be reasonable to simplify the "alternative pathways" effort by focusing on marginal cost per change in emissions, but it will also be important that the comparison be undertaken with respect to the *same* pollutant. Shares of emissions by sector differ significantly for many pollutants. The Council does wish to encourage exploration of how costs are related to emission levels, recognizing that there may be considerable uncertainty in future marginal costs associated with changes in emission, especially where new control technologies are being assumed.

What would be more useful than compound changes is an estimate of marginal costs in different sectors for the same emission reduction beyond current emissions or beyond expected with-CAAA emissions. This could be incorporated into the proposed plans for looking at selected increased control scenarios in excess of those required by the CAAA. One Council Special Panel member highlighted the fact that the goal of air quality attainment is not identical to the goal of maximum net social benefits. Compliance with the NAAQS need not imply maximum risk reduction or maximum net social benefits. The new NAAQS standards will further complicate the task of making this distinction.

- **The "alternative pathways" analyses are somewhat problematic. Unless some analysis of compound changes is specifically required of the Agency, or some specific policy proposal must be considered, it would be preferable to focus instead on exploring the separate marginal effects of shifting abatement responsibility between sectors, one at a time.**

5.4 Benefits NOT constant – spatial heterogeneity

If there are good reasons why the compound changes embodied in the "alternative pathways" analyses must be pursued, there are a number of relevant considerations. For example, there is potential for confusion when changes in the characteristics of different sectors come into play. The Analytical Plan acknowledges that it would be preferable to hold air quality, and thus benefits, constant while exploring the consequences of shifting the burden of emissions reductions across sectors. But this is not really possible, so the Agency will instead to try to hold emissions constant, as far as can be accomplished with the lumpiness of emissions control measures on different sectors.

An example is the current (revised) third "alternative pathway," which involves implementing the electrical generating unit (EGU) cap and trade proposals of the Clear Skies Initiative along with tightening of nitrogen oxide (NOx) and volatile organic compound (VOC) emissions restrictions on motor vehicles, while loosening other CAAA standards for other source categories so that emissions remain at "with-CAAA" levels. This proposed alternative pathway seems to target one important question: namely, what is the appropriate balance between further controls in the electric utility/industrial boilers sector, versus in the transportation sector, to most cost-effectively achieve the new PM and ozone standards.

Given that it is not possible to hold air quality constant in evaluating pathways (and the arguments given for this judgment do seem plausible), then why define the alternatives as "pathways"? They do not reach the same endpoint in terms of benefits. They will be separate scenarios with different implied benefits and costs, and might arise as a result of different regulatory strategies.

The goal of "constant benefits" may be unattainable, but unfortunately so is the goal of "constant emissions." This means the reader is left to compare the implied benefits and costs of some very different strategies that achieve different levels of benefits, even in the aggregate, let alone regionally. There will be differences in ambient concentrations spatially across the different pathways. Thus gainers and losers from each alternative pathway will differ in their distribution across regions. The locations of emission reductions will matter for secondary pollutant formation. Different pathways can involve different spatial patterns of air pollutants and different exposure levels for vulnerable populations, so that human health and ecosystem effects have the potential to differ widely, even if total emissions are held constant.

Ignoring differences in non-health benefits across alternative pathways can impair the usefulness of these planned comparisons, as can the implicit assumption that constant overall emissions equates to constant overall health benefits, even if non-health benefits are identical. These major limitations to the alternative pathway analyses will need to be clearly stated.

With all these limitations, it is not entirely convincing that the proposed analysis of alternative emissions reductions pathways will be all that useful. The Analytical Plan leaves the impression that the Agency's intention is to force all the emissions reductions into one sector or another and see what happens to costs and benefits. Reasonable expectations about increasing marginal costs of control for any given source will lead to higher costs for the same emissions reductions. It is not clear how rigorously demonstrating this will be helpful for policy analysis. There remains the question of whether the quality of the information produced by this exercise, given its limitations, will warrant the effort expended to generate it.

- **It is not possible to hold benefits constant across alternative pathways so that costs can be simply compared. Even if aggregate emissions are held constant,**

there are likely to be substantial differences in health and non-health benefits across regions..

5.5 Attainment outcomes by geographic regions

The Analytical Plan opts to take as given that a certain amount of spatially undifferentiated emissions reduction will need to be achieved, and proposes to explore alternative pathways for reaching that overall level of reduction. The Council concurs that it will be important to focus on the major emitting sectors, yet the proposed alternative pathways may not result in attainment in all geographic regions Under the alternative pathways, some regions will fail to be in attainment. This means it will be necessary to figure out what else is needed to bring them into attainment. The Analytical Plan only undertakes evaluation at ten-year intervals. However, given the algebra of attainment calculations, one needs three years of data in a row to see which areas are in attainment or out of attainment. Progress toward attainment with existing measures will be relevant. The alternative pathway scenarios do not presently include any discussion of expected attainment outcomes.

It would seem if the alternative pathway strategy continues, then in addition to benefits and costs, one would want to know the differences in ambient concentrations of criteria pollutants spatially for different pathways. Some regions may gain and others lose as a result of different pathway assumptions. The Agency should be able to separate the distribution of the benefits (although probably not the costs) by region.

The Agency may wish to follow the lead of the energy forecasting community in formulating their sensitivity analyses in this type of an exercise. It will be important to be candid about the assumptions that are being made, especially concerning such unknowns as how the availability of natural gas in the future will affect the use of coal. This may have a very big effect on emissions for some sectors. These assumptions need to be very explicit, as they affect the details of the model concerning regional effects.

- **If the Agency is obliged to provide some analysis of "alternative pathways" despite the Council's reservations about this exercise, the analysis should accommodate the regional consequences, in particular, the constraints implied by the NAAQS on regional ambient concentrations of pollutants. The criterion that aggregate emissions be held constant across different control strategies will be unlikely to satisfy the NAAQS.**

5.6 Effects on economy, EGUs

In the context of the alternative pathways, many of the same concerns arise as are relevant to evaluating the with-CAAA and without-CAAA scenarios. When the Agency assesses the consequences of shifting around the responsibility for abatement activity among different sectors of the economy, there will be different effects on direct costs, but

these can lead to different effects on output levels, on factor utilization and hence incomes, and therefore potentially very different general equilibrium consequences. Forecasts about the costs of alternative pathways cannot be made without considering their effects on aggregate economic activity, which will of course feed back into the overall levels of emissions.

For example, the treatment of EGUs can have widespread implications for the overall level of economic activity that may differ substantially from those due to regulations on mobile sources that have the same overall effects on emissions. The elasticities of factor demand for electrical energy inputs by various end-users may have a very different character from the elasticities of demand for transportation inputs. EGUs have a huge impact on PM and ozone and this sector will probably experience the greatest increase in costs with aggressive regulation. Assumptions about the degree of substitutability between coal and gas in existing (and in new) generating capacity will have a big effect on the forecasted cost of regulations.

- **If "alternative pathways" are pursued, the same general equilibrium considerations attendant to the main scenario analyses will need to be acknowledged.**

5.7 Miscellaneous

The Council also has some concerns about the process of comparing alternative pathways that involve changes in the timing of implementation for different control requirements. When schedules are changed, the choice of discount rate can be much more important.

There are several types of emissions sources that are not well-quantified. The Agency should be worried more about poorly characterized sources of PM and ambient PM standards.

6 COST ESTIMATES

6.1 Charge Question 7

Does the Council support the plans for estimating, evaluating, and reporting compliance costs described in chapter 4? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

6.2 Econometric models and costs

Econometric models allow the researcher, in principle, to get at indirect effects and behavioral responses to changes in regulations. These models can be used to 1) suggest the magnitude of additional costs beyond direct pollution abatement expenditures, and 2) provide parameters and functions for use in CGE models.

The econometric methods section in the Analytical Plan looks at several different cost studies of specific industries that have tried to isolate the full incremental costs to these industries from abatement activities. EPA's current method for estimating industry costs focuses on the direct cost of abatement equipment as required by the regulations. The value of these econometric studies is that they can suggest the magnitude of the additional costs (or savings) to firms as a result of the direct abatement expenditures. Hence, they suggest whether these indirect effects are important enough that the Agency should worry about capturing them in the 812 analyses.

One type of indirect cost stems from the impacts of abatement activity on total factor productivity. Barbera and McConnell (1990) find some evidence of reductions in total factor productivity in five industries as a result of abatement equipment, but the magnitude of the effect is relatively small. Gray and Shadbegian (1994) and Joshi, Lave, Shih and McMichael (1997) also find evidence of effects on total factor productivity. The estimated effects are relative large for the steel industry.

The other industry study described in Chapter 4 of the analytical plan is that by Morgenstern, Pizer and Shih (2001). This study examines the extent to which a dollar of abatement expenditure can be expected to result in more or less than $1 of expenditure on other non-environmental factors of production in four polluting industries (i.e. are direct abatement expenditures strongly complementary with other inputs, such as specialized labor?). They do not find strong evidence that direct abatement expenditures either over or under-estimate the total costs associated with controls. If anything, there is some indication that abatement expenditures may overstate full costs for some industries.

On net, there is mixed evidence about whether estimating abatement costs by just calculating direct abatement expenditures through engineering cost functions will result in under- or over-estimates of costs in individual industries. It is important to at least review the evidence from this literature, and make a judgment about whether to do any adjustment to forecast of future costs on the basis of the empirical evidence.

The limitations of econometric cost estimation raised on page 4-7 of the Analytical Plan apply with equal force to engineering estimates of future compliance costs, because similar assumptions must be made about factor prices, levels of output produced, and so on. These estimates must be made just as far into the future for engineering cost models as for econometric models. Thus, it is difficult to argue that the described limitations are a particular disadvantage for econometric cost forecasting models as opposed to other types of cost forecasting models. Because these types of

assumptions must also be made for the CGE modeling, how will these separate estimates be reconciled? This issue is not well explained in the Analytical Plan.

In areas where new control technology is needed or costs are highly uncertain, econometric techniques are not a good substitute for uncertainty analysis, relying as they do on observed choices by firms. When no empirical data exist concerning new technologies, expert judgment may be the only available source for information about likely costs.

- **Econometric models for abatement costs are limited by their incomplete coverage but they can sometimes offer insights not available from engineering estimates of compliance costs, in particular, with respect to the impacts of abatement activity on total factor productivity. Econometric models are one important source of the stylized facts about economic relationships that are used to calibrate CGE models.**

6.3 Direct costs versus broader definitions of costs

In the Second Prospective Analysis, the major thrust of the effort to estimate costs is still to forecast the direct abatement costs associated with the CAAA. However, the Analytical Plan does make a number of attempts at capturing broader, more complete estimates of costs. But indirect costs, in the context of the Analytical Plan, are not presently defined very clearly. Whatever the Agency has in mind when it refers to "indirect costs" needs to be spelled out explicitly. It is important to identify what these more-complete measures of cost include and how different they might be from narrowly defined engineering cost estimates.

Some of the relevant indirect costs include costs borne within industries, but other costs stem from productivity effects. Econometric studies can shed some light on how important these additional costs might be. Other relevant indirect costs stem from process changes. Treatment of the effect of learning on costs is addressed in detail below.

Other indirect costs stem from price changes and their effects on consumer behavior in the good market and in the labor market. Regulations change prices which can change behavior. For example, in emissions inspection and maintenance (I/M) programs, significant emissions-related repair costs appear to be inducing some drivers to sell their vehicles outside of the Inspection/Maintenance (I/M) area. This has both costs and benefits beyond the direct effects usually measured for the program.

- **Indirect costs should be defined and itemized more clearly in the Analytical Plan.**

6.4 Validation against realized historical costs

Earlier comments by the Committee have emphasized that it is important to try to validate the assumptions underlying key scenarios in the 812 Analysis. A major refinement in the Second Prospective Analysis will be to enhance validation of the cost forecasts by comparison with historical data and with the results from models which are alternatives to those used in the analysis. This task is very important and the Council applauds the Agency's attempts to do more of this. Earlier ex ante cost (and emissions reductions) forecasts should be compared, where possible, with ex post measurement of these costs in subsequent prospective studies.

CAAA regulations are in many cases designed to encourage innovations and technological advancement to reduce emissions at lower costs. Market based regulations are explicitly designed to do so, but other regulations have also done this—for example, automobile emission limits. It is a huge success story for the CAA that we are enjoying reduced emissions at lower costs than were originally expected. Comparisons with ex post costs are not just a matter of validating previous forecasts, but is also an indication of the effectiveness of the CAA and a potentially important part of the story concerning the costs and benefits of the CAA.

Of course, it will be important to assess whether technologies or processes have changed compared to what was expected when the ex ante forecasts were made. Ex post assessments of the success of prior cost forecasts must be made for the same regulatory program as was assumed in the ex ante prediction exercise, and the same baseline must be used. The predictive model in general may perform well if it is run using the right assumptions, even though it predicts less well if the forecasted determinants of its predictions are less accurate. Predicting the future is never an easy task.

- **Comparison of the predicted and actual costs of air quality regulations will be important to the evolution of the ongoing Section 812 Analyses.**

6.5 Learning

Oversimplification of 80% rule. The effect of "learning" on compliance costs received much emphasis in the document, but the 80% rule for all sectors for a doubling of cumulative production is a gross oversimplification, even though it is an improvement over entirely failing to acknowledge the effect of the learning process on costs. It is hard to come up with a better suggestion than the rule of thumb, but there has been growing experience with compliance costs over the last three decades and it will be important to do the analysis that will allow the rule to be refined.

Across different sectors, there is great variance in the extent to which "learning" can be assumed to decrease compliance costs. The opportunities for reducing costs by learning differ across sectors. There is likely to be extensive heterogeneity.

Alternative conceptualizations of learning. Learning is not carefully enough defined in the Analytical Plan. Does the analysis propose to account for measured "learning curves" in the sense of observed empirical relationships that support the contention that productivity or unit costs are related to cumulative experience with new machinery or processes? (See Argote and Epple (1990).) In an economic context, there has been only a conceptual treatment of this notion of learning (Auerswald et al. (2000)).

Alternatively, does the learning process envisioned by the Agency relate to the learning-by-doing phenomenon that has been suggested to accompany technological innovations? These two perspectives on learning and its effects on costs are related, but formal economic models have been developed for the latter.

Should learning be captured via the discount rate?. A comment was made during the Council's deliberations that the RFF HAIKU model accommodates learning via assumptions about technological change and the Oak Ridge AMIGA model finesses learning through adjustments of the discount rate. It is not at all clear how learning can, or why it should, be incorporated via adjustments to discount rates.

Econometrics of scale effects and learning. The Agency should consider the econometrics of doubling outputs and the empirical evidence about scale economies. The sophistication of these models varies widely across applications. Some models consider a pure learning effect in the form of technical change, while others consider differences in the scale of production and changes in the mix of inputs. It is not even clear that a pure "learning effect" can be empirically isolated.

Meta-analysis. Peretto and Smith (2001) conducted a 48-study meta-analysis of the effects of learning on compliance costs. A PDF file for a recent final report to the U.S. Department of Energy has been provided to the Agency. In that report, pp. 20-25 and Tables 2-9 summarize the database and a preliminary analysis that was conducted for all learning curve studies that the authors could identify, including published and unpublished research.

As the tables in Peretto and Smith document, a diverse set of industries is covered. Unfortunately, none of the studies in the meta-analysis adopted a framework that would be consistent with conventional neoclassical models. While the work of Peretto and Smith remains at an early stage for a meta-analysis, the tables certainly document a simple inventory of what is known. The evidence one can glean from these tables is unfortunately at odds with the contentions of the literature that claims there is empirical support for the 80% rule.

The preliminary results of the Peretto and Smith meta-analysis can thus be characterized as "pretty grim." One would like to identify a range of alternative values by sector for learning effects, but the extant studies vary greatly in terms of their quality. This meta-analysis focused only on energy industries. The central tendency of the magnitude of estimated learning effects suggested by the meta-analysis depends on how the research elects to impose quality control. The distinction between learning via

changes in process versus learning related to "management technique" matters, especially in the service sector.

Additional considerations. The assortment of published models that yield markedly different point estimates for learning effects are frequently inconsistent with neoclassical economics in terms of the use of factor inputs. To be deemed admissible, it would also be desirable for a study to meet higher standards in terms of accounting for technical change.

For cost-savings due to learning, there is a potentially very important question of whether firms enjoy advantages, or suffer penalties, for early implementation of technologies. Being a "first mover" may limit opportunities for learning from the experiences of other firms.

It is not clear that cumulative output is the sole, or best, indicator of learning effects on the eventual costs of abatement activities. The time horizon over which cost reductions due to learning will be exhausted is also not clear. Costs just a few months out may differ substantially from the cost levels that can be attained in the long-term steady-state, even when cumulative production is identical. Eighteen months out, costs can be a little lower, or a lot lower, than the level to which they may fall with early learning.

Process versus industry-specific. It should be emphasized in the 812 analysis that the 80% rule of thumb for learning effects is a gross oversimplification. For example, the effect of learning on compliance costs is more likely to be process-specific, rather than industry specific. Thus it may be inappropriate just to make different assumptions across industries. Instead, the correct "representative" learning effect may depend upon the mix of processes used in each industry.

Desirability/attainability of one number for learning. Despite the preliminary results of the meta-analysis and the absence of any real weight-of-the-evidence conclusions concerning learning effects, it would still be helpful to come up with a best estimate to use for assumptions about cost reductions from experience with compliance technologies. It would be easiest if it were safe to assume a single "learning effect" in the form of an unbiased estimate, neither too high nor too low. However, the effect of learning on costs is likely to display considerable systematic heterogeneity across pollutants and technologies. There is unlikely to be a single "one-size-fits-all" number that is satisfactory for all contexts.

Is it preferable to make an inaccurate adjustment for learning (e.g., when it is not known whether the adjustment should be 10% or 20%) rather than make no adjustment at all, which is known definitely to be incorrect (i.e., there need to be some downward adjustment to costs as a result of learning, but the appropriate magnitude of this adjustment is unclear)? The question of just how much must be known before the Agency is warranted in making a quantitative adjustment permeates many aspects of the Analytical Plan, not just the learning issue, and merits more thought and discussion. In principle, what is desired is the best unbiased estimate, but where is the threshold of

empirical evidence needed to decide upon the appropriate magnitude of that quantitative adjustment?

For example, in its review of the Draft Analytical Plan, two years ago, a majority on the Council agreed that there was insufficient evidence to support using for ecosystem benefits a particular percentage of the Costanza et al. (1998) estimates of total value of the earth's ecosystems. This conclusion was reached in part because there was not sufficient evidence to determine the appropriate percentage of these ecosystems values that would have been lost or reduced without the CAAA.

The Council feels it would be inappropriate to endorse adjustments that have minimal empirical verification as to their specific quantitative values. The cumulative effect of too many such adjustments puts the entire assessment process at risk of losing objective credibility and becoming more a product of subjectivity and political negotiation. The Council encourages the Agency to explore the likely consequences of adjustments that are within the realm of possibility, but not to build in any specific unsupported value for specific adjustments.

Uncertainty analysis. As research into learning effects matures, uncertainty analysis needs to be incorporated to insulate the bottom line from any vulnerability to this problem. There will be deviations from the 80% rule for cost savings. These are likely to differ not just across industries or sectors, but across processes (for example, taking NOx out of coal and gas combustion). These cost savings may be an important issue, but capturing them may require that the corrections to all the way to the process level, not just to the industry level.

The "learning rule" for costs will be refined and tailored to different contexts with the emergence of additional credible research. Until then, and the Agency cannot afford to pursue the same level of detail everywhere, since identifying process- and sector-specific estimates will be very labor-intensive. It would seem most appropriate to tailor the level of detail to the significance of the sector. (McConnell) For example, it will be important to evaluate carefully how the Agency plans to handle learning for the EGU sector.

Miscellaneous. Assumed learning effects depend upon forecasts of cumulative production in each sector. How are these forecasts to be generated? Will cumulative output forecasts be consistent with the CGE models employed elsewhere in the analysis? Page 4-14 of the Analytical Plan is not clear on this point.

The learning in paragraph 2 of mobile sources is completely different than learning [discussed elsewhere] – 80% rule which is on cumulative production. This decrease in annual abatement cost, which is then reduced again??

- **Assumptions about the effect of learning on abatement costs need to be carefully thought-out and supported by the literature in this area. It is not clear that the "80% rule" is valid or even that it is an appropriate place-**

holder in the analysis. Learning effects are likely to be heterogeneous across sectors and processes and no consensus on their magnitude has yet emerged.

6.6 IPM versus HAIKU models for cost estimates

The industrial sector is not completely treated in the proposed analysis. The IPM model focuses on EGUs. ERCAM got at VOC and NOx costs, but nothing else. Fortunately, ControlNet, to be used in the Second Prospective Analysis, covers more than just VOC and NOx. Unfortunately, it is not clear where the rest of the sectors are being treated in this analysis.

The Draft Analytical Plan states that the IPM will be used for utility cost estimates. This model is very good in many ways, but there are a few concerns. One issue is that use of the national-level IPM implies no opportunity for a regional breakdown in direct costs or in local utility regulations. For example, it is the Council's perception that this model assumes efficient pricing everywhere. In many regions there is, and will continue to be, fairly stringent economic regulation of the utility sector. Thus, a capability to do some analysis of EGU environmental regulation at the regional level may continue to be quite important. Comparison to the results of other models, such as the RFF HAIKU model with its more regional focus, will help resolve whether this lack of regionality is a problem for the forecasts of direct costs. While regional impacts are certainly policy relevant, the Council re-affirms its concerns about the general equilibrium consequences of regulation and the difficulty of distinguishing regional effects because of cost spillovers via product, labor, and capital markets.

In addition, the RFF HAIKU model incorporates estimates of consumer and producer surplus (social costs). The relevant question concerns how to account for both industry private costs and social costs.

The IPM model does appear to take account of utility purchase and sale of emission allowances. The initial allocation of those allowances can be very important for the outcome in terms of the final allocation of control responsibility and the resulting costs of control, especially if allowance markets are thin or if unequal market power rests in the hands of some traders. There should be some provision in the proposed analysis for how these allowances are to be allocated initially. Is it assumed they will be auctioned or given away according to some grandfathering formula, or some combination of these two allocation strategies?

- **The IPM exhibits a number of limitations for cost modeling (its lack of coverage, lack of regionality, assumptions of efficient pricing and possibly its assumptions about the initial allocation of emission allowances). All of these problems will need to be addressed carefully.**

6.7 Uncertain future energy demand conditions

Natural gas prices, and assumptions about their future trajectories, will be very important to the forecasting of future costs of the CAAA. The Analytical Plan is not clear about how assumptions about natural gas prices will be made and supported. These assumptions have direct implications for the calculated costs of the CAAA. If the price of natural gas, a cleaner fuel, is much higher than initial estimates, then more of other dirtier fuels will be substituted, and more air quality controls will be needed. Future natural gas prices are a major source of uncertainty in cost forecasts, and sensitivity analysis with respect to different assumptions about these prices will likely be an important part of the uncertainty section of the Second Prospective Analysis.

It will also be important for the Agency to be clear about how demand is determined for the electricity produced by EGUs, and how these demands are regionalized in the models used for cost estimation. Will energy demand models be integrated with the CGE model? In general, fuel prices, energy demand conditions, the competitiveness of different regional (energy) markets, and technical progress assumptions are key ingredients in the forecasting of costs for the utility sector.

- **Future conditions in energy markets may have strong implications for realized abatement costs. Sensitivity of the benefit-cost results to alternative assumptions about energy markets may be an important dimension of the 812 Analysis.**

6.8 Competing risks due to higher energy prices

The Council's report must acknowledge that one Council Special Panel member has drawn attention to the suggestion that the Agency's benefit-cost analysis should not ignore the impact upon health, including both mortality and morbidity for adults and children, from increased energy costs due to air quality regulations (specifically, higher electricity prices). The low-income elderly appear to be especially vulnerable to higher energy costs. This subgroup also appears to be at high health risk for PM exposure. There was a question as to whether it is relevant to compare the direct health risk to the elderly from PM with the indirect health risks stemming from higher energy prices operating through, for example, lesser ability to pay for air conditioning during heat waves or adequate heating during severely cold weather.

It could also be argued that the Agency should consider the health impact of increased prices from air pollution emission controls in other sectors of the economy, such as transportation. The tradeoffs between fuel economy (and its air quality effects) and vehicle weight (and its safety implications) may be equally important in determining competing risks and air quality regulations. These considerations are related to the "richer is safer" literature (also called "health-health analysis"). This literature tries to quantify how regulatory (or other) costs can simultaneously reduce health for some populations, in addition to improving it for others, in ways that might not be fully anticipated. For

example, regulation may also reduce vehicle miles traveled and thereby reduce the risk of highway accident deaths.

The "health-health" approach is useful in policy comparison settings where one looks only at the beneficial health effects of an intervention and ignores the costs. The Council notes that this approach is not as useful, however, in the context of the 812 studies where both health effects and costs are explicitly considered. Such a benefits-only approach would be a new strategy. Since benefit-cost analysis accounts for the costs directly, there is a risk of double counting when the analysis includes both costs and foregone benefits. By foregone benefits is meant the specific goods, such as better health that people give up when they incur regulatory costs, through the richer-is-safer pathway. If the adverse health consequences of higher prices are to be considered for inclusion in the 812 analysis, there will need to be a careful justification for why these costs are not captured directly by the decreases in incomes that are already likely to be part of the explicit costs. This can happen, in principle, when there are externalities involved, but the literature on the existence of such externalities is insufficiently developed. There is also a risk when undertaking a piecemeal accounting of selected general equilibrium effects without considering others. Some secondary effects will be harmful to health, but others will be beneficial. If it is appropriate to address some secondary effects, it is appropriate to consider all of them.

A further difficulty in the richer-is-safer literature is that the empirical estimates are difficult because of the problem of sorting out causality. Income and health are likely to be jointly endogenous. Higher income is likely to promote health, but health may also promote income, and additional factors may contribute to both. The most useful papers in the richer-is-safer literature probably include Chapman and Hariharan (1994, 1996), Keeney (1990, 1997), Lindahl (2002), Lutter, Morrall, and Viscusi (1999), Ruhm (2000, 2003), Smith (1999), and Viscusi (1994).

6.9 Miscellaneous

Problems with Pollution Abatement Cost and Expenditures (PACE) Survey data comparisons. Some of the problems with the PACE data on costs of air pollution control for utilities (identified on page 4-5 of the Analytical Plan) will also afflict direct engineering cost estimates. Neither approach to the calculation of control costs includes process changes or integration of abatement with other firm activities, nor do they include insurance costs. It is important to determine how previous cost forecasts might not be expected to match realized reported PACE costs. Has the Agency determined whether there are any other unique or specialized opportunities to examine data on actual costs or expenditures on air pollution control by electric utilities besides the PACE data? If so, it will be important to take advantage of any reasonable opportunity to validate cost assumptions.

Consistency in interest rate assumptions. Throughout the 812 analysis, there is a need to enforce consistency in key assumptions. For example, is the interest rate being used to annualize costs consistent across sectors and models, and the consistent with the discount rates being used to compare benefits across different time periods? A 5% interest rate is used in the cost analysis. The plan is to convert fixed capital costs to a real capital cost and then to annualize using this interest rate. If 5% is used here, it should also be used elsewhere in the analysis when the same types of time tradeoffs are at stake.

Use of ControlNet. In general, there needs to be more explanation of how ControlNet will be used to develop costs of alternative scenarios. Under certain of the scenarios that will be developed (either the current "alternative pathways" proposed in the Analytical Plan or some revision to those), sectors will require either more or fewer controls depending on the assumptions of the scenario. How are these reallocations of abatement responsibility to be implemented with the ControlNet model? There are many options for control. How is it decided which controls will be used? Even under command and control regulations, there can be various possible ways of achieving goals. How will forecasts be generated concerning how firms will choose between different compliance strategies?

The model used to evaluate some of the scenarios will need to allow for the impacts of changing factor prices. Does ControlNet allow for changes in factor prices? Page 4-6 of the Analytical Plan says it does, but the document is not clear about how. Is it necessary to make specific assumptions about a variety of elasticities, for example? Does ControlNet allow process changes to be built into cost scenarios for alternative pathways (top of page 4-11)? How?

Consideration of National Ambient Air Quality Standards (NAAQS). The approach to construction of cost estimates seems to include too little consideration of the relevance of NAAQS attainment requirements. It appears that the process models do not take into account specific regulations put in place for ambient standards. There is some scope to supplement this analysis with an examination of the PACE data to produce additional checks on the process models. Addressing the same costs using several different approaches will give a better sense of the validity of the cost estimates.

Market Based Incentives (MBI) lower-cost than command and control. In an interesting paper on costs of pollution control, Harrington, Morgenstern and Nelson (2000)[2] found that MBI as pollution control policies have tended to have both lower costs and greater emissions reductions than predicted. This implies that regulations that allow market based solutions should be treated differently in terms of cost estimates. Is this being accounted for in the analysis?

[2] Winston Harrington, Richard D. Morgenstern, and Peter Nelson. 2000. "On the Accuracy of Regulatory Cost Estimates," Journal of Policy Analysis and Management, vol. 19, No.2, pp. 297-322.

- **Other concerns with respect to abatement costs include some caveats about comparisons with the PACE data, the need for consistency in discounting assumptions, some questions about the use of ControlNet, the NAAQS and PACE data, and the relative cost of abatement via market-based instruments versus command and control.**

7 COMPUTABLE GENERAL EQUILIBRIUM MODELING

7.1 Charge Question 8

EPA seeks advice from the Council concerning the choice of Computable General Equilibrium (CGE) model which EPA intends to use as a post-processor to gauge the general equilibrium effects of the various control scenarios. In the first 812 study –the retrospective– EPA used the Jorgenson/Wilcoxen model to gauge the general equilibrium effects of returning to the economy the reported compliance expenditures which formed the basis of the retrospective study direct cost estimates. This model has since been refined in many ways, and EPA considers both the Jorgenson/Wilcoxen/Ho and AMIGA to be acceptable tools. Although a final decision on model choice can be deferred until later in the analysis, EPA has tentative plans to use the AMIGA model because of its greater sectoral disaggregation, better industrial sector matching with CAA-affected industries, richer representation of relevant production and consumption technologies, and better model validation opportunities due to its use of open code. However, AMIGA is limited given its inability to deal with dynamics over time. Does the Council support the current, tentative plan to use the AMIGA model for this purpose? If not, are there alternative model choices or selection criteria the Council recommends?

7.2 Costs outside the regulated market

Theory and empirical work suggest that some of the most important cost-impacts of environmental regulations occur outside of the regulated market. In some circumstances these impacts are of greater magnitude that the impacts in the targeted sector or industry. Thus it seems important for the Agency to consider these impacts in its assessment. The Council commends the Agency for its commitment to addressing these impacts.

- **Incorporation of spillover costs of air quality regulations is important and these costs should continue to receive close attention.**

7.3 Post-processing, or emissions projections too?

It is not clear how the CGE cost estimates will be linked to CGE models.

The Analytical Plan needs to be clear about whether a.) CGE modeling will be done as a "post-processing" exercise with the sole objective of producing more-

comprehensive estimates of overall costs, or b.) CGE models will also be used to help clarify emissions projections.

The existing text of the Analytical Plan suggests that the CGE modeling would serve largely as a check on the direct cost estimates from the engineering and sector studies. This suggests that the CGE analysis largely covers the same impacts as the other models, and it implies a subordinate role for the CGE modeling. This characterization does not to convey the main purpose or significance of the CGE modeling

While CGE models can indeed give information on the direct costs, they are especially important in capturing indirect cost-impacts that cannot be considered by the other analyses. For such impacts, there seems to be no substitute for CGE models. Thus, the discussion of the purpose of CGE analysis should be modified.

CGE models can track the spillovers of air quality management measures into other sectors that are not directly regulated. However, they can also track how emissions regulation will directly affect output and prices in the regulated sectors, and therefore how they will also *indirectly* affect demand and supply conditions in related sectors and thus emissions levels in those sectors.

These secondary general equilibrium effects have the potential to significantly affect overall emissions levels. The Analytical Plan emphasizes the use of CGE models on the cost side, but the Agency must recognize the importance of consistency throughout the set of models used in the analysis. Will there be big changes in emissions in industries that are not being directly regulated, due to shifts in relative prices of inputs and the mix of outputs?

The document should be clear on the relative importance of CGE compared to other analyses of costs. The most crucial aspect of CGE modeling is that it provides information on indirect costs, which may be substantial. General equilibrium effects of regulations are not captured in any of the direct cost calculations. What the Analytical Plan currently describes is NOT the emphasis that is appropriate.

- **CGE models have the capability to reveal spillovers of air quality regulations into unregulated sectors, not just to better estimate the direct costs of regulation on regulated sectors. The current Analytical Plan describes CGE methods only for "post-processing" and relegates them to secondary status. General equilibrium modeling should enjoy similar status to direct cost calculations.**

7.4 Competing CGE models

Jorgenson-Ho-Wilcoxen (JGW) model track record. The Analytical Plan recommends the use of the (JGW model for the CGE analysis. This model has

continually improved over the years and has a long history of peer review. Its most important virtues are:

(1) attention to margins of substitution among factors, inputs, and goods which seem most important *a priori*,
(2) a serious empirical (econometric) basis for its parameters,
(3) careful modeling of saving behavior, capital demands and technological change,
(4) significant degree of sectoral disaggregation, and
(5) incorporation of pre-existing distortionary taxes. (The significance of this last feature is discussed below.)

Like all models, this model also has some limitations. These include an overly optimistic specification of the sectoral mobility of capital (it is assumed to be perfectly mobile), excessively elastic savings behavior, and the absence of explicit modeling of natural resource stocks and associated extraction-cost implications. However, for the purpose of gauging the general equilibrium cost impacts, this model is, overall, probably a good choice.

It will be important to explain further the choice of CGE model, even if it to be used only for the "post-processing" tasks. The Jorgenson-Ho-Wilcoxen model and the AMIGA model are the current contenders. The JHW model has many antecedents in the literature, and while it is not perfect, it does capture a lot of processes that are crucial to our understanding of the responses of the economy to air quality regulations. It incorporates an elastic treatment of capital and has a good representation of savings behavior. However, its treatment of natural resource stocks is rudimentary and issues of exhaustibility of domestic petroleum stocks are not adequately represented. One attractive feature of the JHW model is that is has been extensively peer-reviewed and is "about as good as it gets" among the class of thoroughly vetted models.

AMIGA model; validation. The Analytical Plan also refers to the AMIGA model as a possible vehicle for CGE analysis. As of the present point in this review process, few members of the Council are sufficiently familiar with the details of this model. It is important for the Council to examine this model carefully during the review process before making any suggestions about its suitability. The Agency has provided supplementary review materials.

In contrast to the Jorgenson-Ho-Wilcoxen model, the AMIGA model has no track record in peer-reviewed journals. It is a "new entrant." There is one paper forthcoming. It will be necessary for the Agency to examine the model very closely to compensate for the lack of peer review. It will be important to assess the relationship between current conditions and the prediction of the AMIGA model based on earlier conditions, to see how well the AMIGA model can predict realized historical outcomes. This needs to be done to reinforce our confidence in how well the AMIGA model might perform in predicting future developments.

On pages 4-23, the document describes a number of what are described as "minor concerns". The last is described as follows: "…for consumption of goods other than transportation and housing-related services, the *model's implicit assumption of zero substitutability may not be supported empirically"* (emphasis added). The Analytical Plan does not contain sufficient information about the AMIGA model for the reader to understand this comment. If it implies that the AMIGA model assumes that all commodities except housing and transportation are consumed in fixed proportions, then this is a very restrictive assumption.

It is not at all clear how the model can deal with any form of substitution in consumption if there are effectively no demand curves in this model for most types of goods. The "deadweight losses" due to taxation occur because these taxes drive a wedge between buyer's gross prices and the seller's net prices of a variety of goods. If demand is unresponsive to prices, quantities traded will not change and the analysis will not be able to capture these deadweight losses, which almost certainly will be present. It may be the case, however, that the description of this aspect of the model in the Analytical Plan is just prone to misinterpretation.

The Council wishes to emphasize that use of the AMIGA model, if it does indeed embody a zero substitution assumption, would be inconsistent with the objective of a CGE analysis. That objective is to reflect inter-sectoral substitution effects of the costs that arise from environmental policies. A choice to use AMIGA by the Agency would reduce the standing of the CGE analysis in relationship to other cost analyses.

- **Each of the main CGE models which are proposed for use in the 812 Analysis has some limitations. The JHW model has a longer track record and has been more extensively reviewed. The zero-substitutability assumption apparently made in the AMIGA model represents a major cause for concern to the Council.**

7.5 The tax-interaction effect

Two years ago, in its preliminary review of the Draft Analytical Plan, the Council was disappointed about the Agency's treatment of the tax interaction effect. The literature indicates that the tax interaction effect is not just a second-order effect, but a first-order effect, and it therefore needs greater status in the analysis. The Council endorses the Agency's commitment to attend to this effect in its current study.

Overview. The tax-interaction effect stems from the impact of environmental regulations on relative prices. In particular, to the extent that regulations raise costs and lead to higher output prices, they raise the prices of goods in general. This effectively lowers the real returns to factors of production (e.g., the real wage). To the extent that pre-existing taxes have already reduced factor supplies below the efficient level, the further reduction in factor returns stemming from higher goods prices produces a first-

order efficiency loss. This is the tax-interaction effect. In several studies, this effect involves a greater cost than the direct cost or compliance cost in the regulated market.

The Analytical Plan's characterization of the tax-interaction effect still has some problems. The Plan correctly points out that there is uncertainty surrounding the magnitude and sign of the tax-interaction effect. However, it incorrectly concludes from this that the central case estimates should assume that this effect is zero. It is more appropriate to use a best estimate of the mean of the tax-interaction effect.

Both theoretical and empirical studies consistently indicate that, in realistic settings, the tax-interaction effect involves a positive cost. Moreover, for environmental regulations that do not raise revenue – for example, performance standards, technology mandates, or freely allocated emissions permits – there is no "revenue-recycling effect" to offset the tax-interaction effect. For these regulations, if the required emissions reduction is a small percent of baseline emissions, the tax-interaction effect can be several times larger than the direct costs.

The tax-interaction effect will be smaller to the extent that the regulated commodity is an especially strong complement to leisure. However, even in this case this effect will generally imply an extra cost rather than a reduction in cost. The regulated commodity would have to be an extremely strong leisure complement to switch the sign of the tax-interaction effect.

Benefits-side tax-interaction effect. The general equilibrium effects of compliance costs are critical, but so may be the general equilibrium effects of beneficial health changes. Abatement of air pollution by the CAAA is intended to create positive health effects. It is just as important that the analysis not overlook the general equilibrium consequences of improved health status on labor availability and productivity, and therefore on the cost of labor, and on the costs of health care. Morbidity certainly has indirect effects on productivity that need to be recognized. General health consequences of changes in the ambient levels of pollutants need to be considered, not just mortality.

The impact of regulations on labor productivity and the associated "benefit-side" tax-interaction effect is indeed an important issue, and has been analyzed specifically by Williams (2002, 2003). This beneficial effect offsets the adverse tax-interaction effect described in the previous section. However, Williams's work indicates that, in general, this offset is not likely to be large enough to entirely offset the adverse tax-interaction effect. Thus it seems appropriate to assume in the central case that the tax-interaction effect does raise costs.

On page 4-26, the Analytical Plan suggests that: "Improvements in CGE models that the Agency is considering for this analysis have made it possible to account for tax interaction effects more precisely." The Council assumes that this comment pertains only to indirect effects on the cost side of the analysis, not the benefits. Part of the tax interaction effect can be addressed in CGE models, but no existing CGE model will

capture all of it. At a minimum the Williams' (2002, 2003) adjustments for the productivity-enhancing consequences of health improvements due to environmental regulations need to be considered.

However, there are in fact a number of citations concerning the health benefits of emissions controls for labor productivity and their spillovers into less-regulated sectors. The Council is aware of several papers on this topic. Some of these papers (e.g. Espinosa and Smith, 1995) demonstrate how non-separability between pollutants and private goods, a prerequisite for such beneficial spillovers, can be incorporated into CGE models.

Two of the already-published papers in this literature are Espinosa and Smith (1995) and Smith and Espinosa (1996).[3] These papers use an updated version of the Harrison-Rutherford-Wooton model that includes measures of particulate matter, sulfur dioxides, and nitrogen oxides as non-separable influences on consumer preferences. The model includes eleven regions and six goods and three factors in each region. International trade and transboundary pollution are included. There is a simple air diffusion model between the different countries in Europe. The model relies on the concentration response functions presented in Desvousges, Johnson, and Banzhaf (1998) and uses estimates of willingness to pay that are adjusted for each country. A newer paper that addresses the tax interaction effects, Espinosa and Smith (2000) is under review for publication.

The Committee endorses a balanced approach to CGE modeling, so that indirect *benefits* as well as indirect costs are considered.

Tax-interactions should be explicit. The tax interaction effect should be an explicit dimension of the presentation of costs. The precise methods for including tax interaction considerations in the Second Prospective Analysis are not adequately described in the current Analytical Plan. The Council could be more confident in its advice on this matter if the Analytical Plan included more-specific details on these issues, including a description of how engineering cost estimates will be linked to the CGE models for the analysis of tax interaction effects.

It should be noted that the Analytical Plan's suggestion of a 25-35% increase in costs due to the tax interaction effect in the current document may be a result of miscommunication in, or misinterpretation of, the earlier Council review of the Draft Analytical Plan. The indirect cost consequences of the tax interaction effect can differ by orders of magnitude, and can be vastly larger when regulations actually result in little abatement and when there is no revenue recycling. For the SO2 emissions covered by Title IV, it may be appropriate to make the assumption of a 25-30% increase in costs, but such an assumption is unlikely to be universally appropriate.

The question thus remains as to how large a cost-impact the Agency might assume for tax interactions. The Agency could address this issue two ways. First, it can

[3] The fifth one is in *Environmental and Resource Economics*; I have not located my copy. It is a conceptual paper Schwartz and Repetto (2000)

employ its commissioned CGE model or models to evaluate the costs of specific regulations. The tax-interaction effect should be embodied in the aggregate cost-impacts obtained from such models. Second, the Agency should consult results from other, prior CGE studies of particular regulations. This second step will be useful as a cross-check on the results from the Agency's commissioned model or models. Moreover, this second step may be necessary to obtain general equilibrium cost-estimates in some instances, since there will surely be some particular regulations that the commissioned model or models cannot capture.

Given the uncertainties surrounding the magnitude of the tax-interaction effect and of cost-impacts in general, it is very important that the Agency require considerable sensitivity analysis in its CGE assessments. Past applications of the Jorgenson-Ho-Wilcoxen model have tended to skimp on sensitivity analysis.

- **The Council advocates a serious effort to accommodate the consequences of possible tax interactions in the 812 Analysis. Considerable sensitivity analysis is indicated, however, since simple formulas for the magnitudes of tax interactions for regulations imposed on particular sectors have not yet been identified.**

7.6 Tension between CGE, econometric models

The Analytical Plan rejects econometric methods for developing cost estimates but accepts CGE models. This sort of top-down approach in the cost calculations, embracing CGE models, is puzzling. The Council feels that both types of models should be informative. Their implications should be convergent, and a plurality of methods is desirable. However, it is possible that the implications of the different approaches will not be convergent. If this is the case, then there is a clear need for more basic research to resolve the conflicts.

One way or another, the analysis needs to attend to general equilibrium effects. In terms of first-order effects, however, it is likely that most of the cost impacts on other markets are likely to work through their interactions with electricity markets.

Are CGE models sufficiently comprehensive? Some members of the Council have voiced a concern about whether even the largest CGE models are large enough? These are based on empirical studies of individual industries, but more coverage is certainly needed. There is not presently enough coverage by empirical studies to permit reliance on econometric models exclusively. CGE models are calibrated on a selection of empirical results and researchers can then rely upon plausible assumptions, informed by expert opinion, to fill in for missing information.

There could, however, be more use of engineering and expert judgment when empirical results from econometric models are absent. The analysis could proceed based on expert judgments, using an engineering "bottom-up" strategy. For example,

assumptions about the availability of natural gas will be critical to forecasts. Even the experts do not know enough about the determinants of availability of natural gas to base the modeling assumptions on existing empirical results, so the analysis may need to rely more heavily on engineering expert judgment.

- **CGE models and econometric models for costs are not competing methods, but complementary methods. Econometric results, where available and appropriate, are generally more desirable than expert judgment for calibrating the parameters of CGE models. However, where no econometric estimates exist for key parameters, expert judgment is essential.**

8 DISCOUNTING

8.1 Charge Question 9:

In the two previous 812 studies, the primary cost estimates reflected use of a 5 percent real discount rate, which an earlier Council endorsed as a reasonable compromise between a 3 percent real rate considered by EPA to be an appropriate estimate of the consumption rate of interest or rate of social time preference and a 7 percent rate, OMB's estimate of the opportunity cost of capital. Limited sensitivity testing was also conducted in the previous 812 studies by substituting 3 and 7 percent rates to annualize the benefit and cost streams. EPA's new Economics Guidelines (peer-reviewed by the SAB EEAC) call for using both a 3 and a 7 percent rate. A recent draft of new OMB economic guidelines suggests providing results based on both 3 and 7 percent discount rates, while also acknowledging the need for further efforts to refine analytical policies for discounting methods and rates. EPA plans on following both sets of Guideline documents by using both 3 and 7 percent in our core analyses. It is true that this will require presentation of two sets of results – one based on each rate. This may not be necessary given the expected insensitivity of the overall results to the discount rate assumption. Does the Council support this approach? If not, are there alternative rates, discounting concepts, methods, or results presentation approaches the Council recommends?

8.2 Theory

There are important theoretical (and therefore empirical) differences between the discounting of future consumption streams and the discounting of future utility levels. As the Analytical Plan indicates, the theoretically appropriate rate at which to discount future values (benefits and costs, as opposed to future utilities) is the sum of a pure social rate of time preference and an adjustment term reflecting future changes in the marginal utility of consumption (future goods may be worth less at the margin as people get richer). The elasticity of the marginal utility of consumption is important. The researcher still might want to use a positive discount rate even if the first term is zero.

There is considerable discussion about whether the social rate of time preference should be revealed by markets, but there are a number of reasons why the market does not give reliable information. There is actually no clear connection between the social rate of time preference and market interest rates. One reason is that the appropriate rate for public decisions need not conform to the discount rates that individuals apply in their private decisions. As social beings, we may collectively endorse a discount rate that differs from the rate we apply privately.

Even if one were to adopt the assumption that the social discount rate should reflect private preferences, the appropriate social discount rate will still differ from market rates. The 7% rate advocated by the Office of Management and Budget is based upon the opportunity cost of capital. However, externalities, taxes on capital, and inability to pool risks perfectly can all cause market interest rates (that firm's opportunity costs of capital) to differ significantly from individuals' inherent rates of exchange between future and current goods.

A recent survey concerning discounting and the rate of time preference (Frederick et al., 2002) reveals broad heterogeneity in individual discount rates and systematic effects upon discounting that depend upon the context of the choice. The choice context includes the time horizon over which the discounting is to occur, the sizes of the benefits and costs at stake, and a number of sociodemographic factors. See also Warner and Pleeter (2001), Harrison et al. (2002) and Cameron and Gerdes (2002). There is no single private discount rate that can be readily translated into a social discount rate for use in collective choice in all possible social choice situations.

- **The discounting of future benefits and costs by individuals is a complex cognitive process and the literature on discounting is replete with empirical anomalies. Economic theory provides a framework for thinking about the appropriate common discount rate to use in discounting aggregate future net social benefits. However, exactly what social discount rate is the "right" single common rate is remains subjective and a matter of debate. Time preferences in a population depend upon the particular choice context, which includes factors as diverse as the time horizon, the sizes of the benefits and costs, and the distribution of subjective life expectancies in the affected population.**

8.3 Guidelines for economic analysis

It is crucial that the Analytical Plan reiterate the general issues surrounding discount rates. The relevance of discounting stems from the details of changes in abatement costs and benefits over time, across different scenarios. When costs and benefits are not identically distributed over time, the discount rate assumptions in the analysis will be important.

The strategy for calculating firms' annualized private costs using some specific discount rate in conjunction with the cost of specific abatement measures needs to be consistent with the way that the social benefit cost-analysis is conducted. There should to be more detail used in describing time-profiles of costs and benefits in the different scenarios. The sensitivity of the conclusions to different discount rates and different assumptions about time profiles needs to be featured prominently. The Council addresses this issue further in its discussion of the material in Chapter 11 of the Revised Analytical Plan.

The current guidelines for benefit-cost analysis recommend 3% and 7%, along with a complementary undiscounted time stream of benefits and costs with zero discounting.

- **The 812 Analysis should conform to the recommended treatment of discounting spelled out in the EPA's Guidelines for Benefit-Cost Analysis. Deviations from this advice are admissible, of course, but they should be explained and justified by more-recent research.**

8.4 Central assumption and sensitivity analysis

Faced with the subtleties of conceptualizing the appropriate common social discount rate for future aggregate net benefits, it is entirely appropriate, indeed crucial, to apply a range of values for the social discount rate. The Agency has floated the possibility of performing all analyses with a 3 percent rate and a 7 percent rate. The Council recommends instead using a "central" value of 4 or 5 percent, and then including lower and higher rates as a sensitivity analysis. Using a central value, along with variations on each side of this value, is the standard sensitivity approach. However, the Council acknowledges that using a "central" value runs the risk that readers will focus exclusively on this central case. This problem must be weighed against the inherent awkwardness of not having a central case.

The Council wishes to emphasize the importance of how the Agency chooses to present the results concerning sensitivity of the benefit-cost analysis to assumptions about discounting. The choice between presenting a measure of central tendency, or an interval, may be an important one. Intervals may lead people to ignore the results. It can be argued that it is easier to interpret the results of an analysis when using a central tendency rather than a range, but it will be crucial to capture the consequences of uncertainty about appropriate discounting decisions. The opportunity cost of capital, on net, may be a reliable guide to the upper end at about 7%. The lower end of the range could 3% or less. So the 2-7% range in rates may be the most appropriate.

The Council commends the Agency's focus on the uncertainty surrounding the appropriate rate at which to discount future benefits and costs. It is very important to do sensitivity analysis based on a 4% or 5% mean, rather than settling on just one rate for the entire analysis, or just a pair of "spanning" rates. In general, the Second Prospective Analysis should conform as closely as possible to the Agency's own Guidelines for Economic Analysis, or justify carefully any departures.

- The reported results of the Agency's benefit-cost analysis should make clear the extent to which uncertainty about the bottom line depends upon assumptions about the appropriate social discount rate.

8.5 Consistency throughout the Analytical Plan

Finally, the Agency should strive for consistency in its application of the discount rate. In particular, some of the sector-specific models may be applying a different discount rate from the "social" rate that is appropriate for a (social) benefit-cost analysis. In particular, they may be applying firms' opportunity costs of capital. While this opportunity cost is appropriate for characterizing costs or benefits to firms, it does not correspond to social costs or benefits. Thus, if these models employ a different discount rate, a further adjustment would be necessary to arrive at social benefits and costs.

Another discounting issue concerns the disparity between how the Plan characterizes the private discount rates used by firms, the market rates faced by individuals, and actual conditions at the time the analysis is being done. Interest rates are not constant over time. Mortgage rates currently hover around 6%, passbook saving and CD rates are around 1-2%. Even consumer credit rates have come down. It may be important for the Agency's discussion of private and social rates of discount to reflect the consequences of what has been a fairly long period of exceptionally low rates.

There is also another interest/discounting issue that must be discussed more transparently. In the estimation of private costs of pollution abatement equipment, what private rate is used to compute annual costs to each sector? Any disparities between these rates represent another potentially important source of inconsistency between the cost analysis and the CGE model. The Council has found that there is insufficient detail in the Draft Analytical Plan to permit a clear understanding of the different strategies to be employed in annualizing private abatement costs forward, versus discounting aggregate future net social benefits. The Council has requested that the Agency provide more detail.

- **Wherever the 812 Analysis must accommodate non-contemporaneous benefits and costs, the discount rate that is used should be consistent. Exceptions should be justified by large differences in the time horizons involved or perhaps large differences in the ages of the affected populations, supported by empirical results to back up any assumed differences.**

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Appendix A

SAB Review Charge Questions

July 3, 2003 – REVISED

This document conveys a set of specific charge questions which EPA respectfully requests that the SAB Council consider during its review of the draft analytical blueprint for the upcoming section 812 benefit-cost study of the Clean Air Act. The charge questions are organized by blueprint chapter or appendix. The first question posed for each chapter or appendix is intended to serve as a general charge question consistent with the statutory criteria for Council review of the section 812 studies. Additional, more detailed charge questions are also conveyed for most chapters and appendices. These supplemental charge questions reflect EPA's desire to obtain specific and detailed advice from the Council on particular analytical issues.

Chapter 1: Project Goals and Analytical Sequence

1. Does the Council support the study goals, general analytical framework, disaggregation plan, analytical sequence, and general analytical refinements defined in chapter 1? If there are particular elements of these plans which the Council does not support, are there alternatives the Council recommends?

Chapter 2: Scenario Development

2. Does the Council support the choices for analytical scenarios defined in chapter 2? Are there alternative or additional scenarios the Council recommends EPA consider for inclusion in the analysis?

3. Does the Council support the alternative compliance pathway estimation and comparison methodology described in chapter 2, including the specification of alternative compliance pathways which may not reflect precisely constant emissions or air quality outcomes between scenarios due (primarily) to the non-continuous nature and interaction effects of emission control options?

Chapter 3: Emissions Estimation

4. Does the Council support the plans for estimating, evaluating, and reporting emissions changes as defined in chapter 3? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

5. Chapter 3 of the analytical plan describes several alternative approaches considered by EPA for estimating non-EGU emissions growth rates. These options reflect different relative emphasis between two conflicting analytical objectives: (1) extensive refinement of the geographically differentiated, source-specific economic activity growth estimates embedded in EGAS 4.0, and (2) maintaining the current project schedule and budget. EPA plans to use "approach

#4", a compromise option which targets the most important source categories for potential refinement. Does the Council support the initial plan to use "approach #4"? If the Council does not support the use of approach #4, are there other approaches –including either the approaches described in chapter 3 or others identified by the Council– which the Council suggests EPA consider?

6. Some state-supplied emissions data incorporated in the 1999 National Emissions Inventory (NEI) –the core emissions inventory for this analysis– incorporate different emissions factors from those used in MOBILE6, the mobile source emissions model EPA plans to use for estimating emissions changes between scenarios. Of particular importance, some of the emissions factors embedded in California's EMFAC model may be significantly different from factors used in MOBILE6. EPA considered three options for estimating emissions changes in California, which are described in chapter 3. EPA plans to implement option #3 based on the belief that the emission factors embedded by California in its EMFAC model may be more accurate for their particular state than the factors incorporated in MOBILE6. Does the Council support the plan to implement option #3? If the Council does not support the adoption of option #3, are there other options –including either the options described in chapter 3 or others identified by the Council– which the Council suggests EPA consider?

Chapter 4: Cost Estimates

7. Does the Council support the plans for estimating, evaluating, and reporting compliance costs described in chapter 4? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

8. EPA seeks advice from the Council concerning the choice of Computable General Equilibrium (CGE) model which EPA intends to use as a post-processor to gauge the general equilibrium effects of the various control scenarios. In the first 812 study –the retrospective– EPA used the Jorgenson/Wilcoxen model to gauge the general equilibrium effects of returning to the economy the reported compliance expenditures which formed the basis of the retrospective study direct cost estimates. This model has since been refined in many ways, and EPA considers both the Jorgenson/Wilcoxen/Ho and AMIGA to be acceptable tools. Although a final decision on model choice can be deferred until later in the analysis, EPA has tentative plans to use the AMIGA model because of its greater sectoral disaggregation, better industrial sector matching with CAA-affected industries, richer representation of relevant production and consumption technologies, and better model validation opportunities due to its use of open code. However, AMIGA is limited given its inability to deal with dynamics over time. Does the Council support the current, tentative plan to use the AMIGA model for this purpose? If not, are there alternative model choices or selection criteria the Council recommends?

In the two previous 812 studies, the primary cost estimates reflected use of a 5 percent real discount rate, which an earlier Council endorsed as a reasonable compromise between a 3 percent real rate considered by EPA to be an appropriate estimate of the consumption rate of interest or rate of social time preference and a 7 percent rate, OMB's estimate of the opportunity cost of capital. Limited sensitivity testing was also conducted in the previous 812 studies by substituting 3 and 7 percent rates to annualize the benefit and cost streams. EPA's new Economics Guidelines (peer-reviewed by the SAB EEAC) call for using both a 3 and a 7 percent rate. A recent draft of new OMB economic guidelines suggests providing results based on both 3 and 7 percent discount rates, while also acknowledging the need for further efforts to refine analytical policies for discounting methods and rates. EPA plans on following both sets of Guideline documents by using both 3 and 7 percent in our core analyses. It is true that this will require presentation of two sets of results – one based on each rate. This may not be necessary given the expected insensitivity of the overall results to the discount rate assumption. Does the Council support this approach? If not, are there alternative rates, discounting concepts, methods, or results presentation approaches the Council recommends?

Chapter 5: Air Quality Modeling

Does the Council support the plans described in chapter 5 for estimating, evaluating, and reporting air quality changes associated with the analytical scenarios? If there are particular elements of these plans which the Council does not support, are there alternative data, models, or methods the Council recommends?

Chapter 6: Human Health Effects Estimation

Does the Council support the plans described in chapter 6 for estimating, evaluating, and reporting changes in health effect outcomes between scenarios? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

EPA seeks advice from the Council regarding the technical and scientific merits of incorporating several new or revised endpoint treatments in the current analysis. These health effect endpoints include:

a. Premature mortality from particulate matter in adults 30 and over, PM (Krewski et al., 2000);
b. A PM premature mortality supplemental calculation for adults 30 and over using the Pope 2002 ACS follow-up study with regional controls;
c. Hospital admissions for all cardiovascular causes in adults 20-64, PM (Moolgavkar et al., 2000);
d. ER visits for asthma in children 0-18, PM (Norris et al., 1999);
e. Non-fatal heart attacks, adults over 30, PM (Peters et al., 2001);
f. School loss days, Ozone (Gilliland et al., 2001; Chen et al., 2000);
g. Hospital admissions for all respiratory causes in children under 2, Ozone (Burnett et al., 2001); and,

h. Revised sources for concentration-response functions for hospital admission for pneumonia, COPD, and total cardiovascular: Samet et al., 2000 (a PM10 study), to Lippmann et al., 2000 and Moolgavkar, 2000 (PM2.5 studies).

13. EPA seeks advice from the Council regarding the merits of applying updated data for baseline health effect incidences, prevalence rates, and other population characteristics as described in chapter 6. These updated incidence/prevalence data include:

a. Updated county-level mortality rates (all-cause, non-accidental, cardiopulmonary, lung cancer, COPD) from 1994-1996 to 1996-1998 using the CDC Wonder Database;
b. Updated hospitalization rates from 1994 to 1999 and switched from national rates to regional rates using 1999 National Hospital Discharge Survey results;
c. Developed regional emergency room visit rates using results of the 2000 National Hospital Ambulatory Medical Care Survey;
d. Updated prevalence of asthma and chronic bronchitis to 1999 using results of the National Health Interview Survey (HIS), as reported by the American Lung Association (ALA), 2002;
e. Developed non-fatal heart attack incidence rates based on National Hospital Discharge Survey results;
f. Updated the national acute bronchitis incidence rate using HIS data as reported in ALA, 2002, Table 11;
g. Updated the work loss days rate using the 1996 HIS data, as reported in Adams, et al. 1999, Table 41;
h. Developed school absence rates using data from the National Center for Education Statistics and the 1996 HIS, as reported in Adams, et al., 1999, Table 46.
1. Developed baseline incidence rates for respiratory symptoms in asthmatics, based on epidemiological studies (Ostro et al. 2001; Vedal et al. 1998; Yu et al; 2000; McConnell et al., 1999; Pope et al., 1991).

14. EPA plans to initiate an expert elicitation process to develop a probability-based method for estimating changes in incidence of PM-related premature mortality. Plans for this expert elicitation are described in chapter 9 of this blueprint, and a separate charge question below requests advice from the Council pertaining to the merits of the design of this expert elicitation. EPA recognizes, however, the possibility that this expert elicitation process may not be fully successful and/or may not be completed in time to support the current 812 analysis. Therefore, in order to facilitate effective planning and execution of the early analytical steps which provide inputs to the concentration-response calculations, EPA seeks advice from the Council regarding the scientific merits of alternative methods for estimating the incidences of PM-related premature mortality, including advice

pertaining to the most scientifically defensible choices for the following specific factors:

a. Use of cohort mortality studies, daily mortality studies, or some combination of the two types of studies
b. Selection of specific studies for estimating long-term and/or short-term mortality effects
c. Methods for addressing –either quantitatively or qualitatively– uncertain factors associated with the relevant concentration-response function(s), including
    i. Shape of the PM mortality C-R function (e.g., existence of a threshold),
    ii. PM causality,
    iii. PM component relative toxicity, and
    iv. PM mortality effect cessation lag structure
    v. Cause of death and underlying health conditions for individuals dying prematurely due to chronic and/or short term exposures to particulate matter
    vi. The use of ambient measures of exposure for estimating chronic health effects, given recent research reviewed in the NAS (2002) report that questions the implications of using ambient measures in cohort studies

15. EPA estimates of benefit from particulate control may underestimate the impact of nonfatal cardiopulmonary events on premature mortality and life expectancy. For the base analyses, which rely on cohort evidence, the limited follow-up periods for the cohorts may not fully capture the impacts of nonfatal cardiovascular events on premature mortality later in life. For the alternative analyses –including cost-effectiveness analyses– which rely more on acute studies and life-expectancy loss, the years of life are estimated only for fatal events. Yet nonfatal events such as myocardial infarction reduce a person's life expectancy by a substantial percentage.
    a. Do you agree that EPA, in the 812 analyses, should adjust benefit estimates to account for the mortality effects of non-fatal cardiovascular and respiratory events?
    b. What medical studies and mathematical models of disease might be useful to review or use if EPA moves in this direction?
    c. When the nonfatal events are valued in economic terms, should EPA assume that the published unit values for morbidity already account for the life-expectancy loss or should an explicit effort be made to monetize the resulting longevity losses?

16. In recent EPA rulemakings, EPA's "base estimate" of benefit from PM control has been based on cohort epidemiological studies that characterize the chronic effects of pollution exposure on premature death as well as capturing a fraction of acute premature mortality effects. If these chronic effects occur only after repeated, long-term exposures, there could be a substantial latency period and associated

cessation lag. As such, a proper benefits analysis must consider any time delay between reductions in exposure and reductions in mortality rates. For the acute effects, such as those considered in EPA's alternative benefit analyses, the delays between elevated exposure and death are short (less than two months), and thus time-preference adjustments are not necessary.

a. In the previous 812 analysis and in recent rulemakings, EPA assumed a weighted 5-year time course of benefits in which 25% of the PM-related mortality benefits were assumed to occur in the first and second year, and 16.7% were assumed to occur in each of the remaining 3 years. Although this procedure was endorsed by SAB, the recent NAS report (2002) found "little justification" for a 5-year time course and recommended that a range of assumptions be made with associated probabilities for their plausibility. Do you agree with the NAS report that EPA should no longer use the deterministic, 5-year time course?

b. One alternative EPA is considering is to use a range of lag structures from 0 to 20-30 years, with the latter mentioned by NAS in reference to the Nyberg et al PM lung cancer study, with 10 or 15 years selected as the mid-point value until more definitive information becomes available. If this simple approach is used, should it be applied to the entire mortality association characterized in the cohort studies, or only to the difference between the larger mortality effect characterized in the cohort studies and the somewhat smaller effect found in the time series studies of acute exposure? Should judgmental probabilities be applied to different lags, as suggested by NAS?

c. Another option under consideration is to construct a 3-parameter Weibull probability distribution for the population mean duration of the PM mortality cessation lag. The Weibull distribution is commonly used to represent probabilities based on expert judgment, with the 3-parameter version allowing the shaping of the probability density function to match expected low, most likely, and expected high values. EPA is still considering appropriate values for the low, most likely, and expected high values –and therefore for the Weibull shape and location parameters– and EPA is interested in any advice the Council wishes to provide pertaining to the merits of this approach and/or reasonable values for the probability distribution.

17. In support of Clear Skies and several recent rule makings the Agency has presented an Alternative Estimate of benefits as well as the Base Estimate. EPA developed the Alternative Estimate as an interim approach until the Agency completes a formal probabilistic analysis of benefits. NAS (2002) reinforced the need for a probabilistic analysis. The Alternative Estimate is not intended as a substitute method and needs to be considered in conjunction with the Base Estimate. Presentation of Base and Alternative estimates in the 812 Report may not be necessary if the probability analysis planned for the 812 Report is successful. While the Base Estimate assumes that acute and chronic mortality effects are causally related to pollution exposure, the Alternative Estimate

assumes only acute effects occur or that any chronic effects are smaller in size than assumed in the Base Estimate. The Council's advice is sought on the following matters:

a. It has been noted by some particle scientists that the size of estimates based on time series studies that incorporate a distributed lag model, accounting for effects of 30 to 60 days after elevated exposure, may be similar in size to some interpretations of the results from the cohort studies. Does the Council agree that it is a reasonable alternative to use an estimate of the concentration-response function consistent with this view? If the Council agrees with the assumption, can it suggest an improved approach for use in an Alternative Estimate? The agency also seeks advice on appropriate bounds for a sensitivity analysis of the mortality estimate to be used in support of the Alternative Estimate.

b. An assumption that a specific proportion of the PM-related premature mortality incidences are incurred by people with pre-existing Chronic Obstructive Pulmonary Disease (COPD) and that these incidences are associated with a loss of six months of life, regardless of age at death. If these values are not valid, what values would be more appropriate? Do you recommend a sensitivity analysis of 1 to 14 years (with the latter based on standard life tables), as included in the draft regulatory impact analysis of the proposed Nonroad diesel rule?

c. An assumption that the non-COPD incidences of PM-related premature mortality are associated with a loss of five years of life, regardless of age at death. If these values are not valid, what values would be more appropriate? Do you recommend a sensitivity analysis of 1 to 14 years (with the latter based on standard life tables), as included in the draft regulatory impact analysis of the proposed Nonroad diesel rule?

d. Additional quantified and/or monetized effects are those presented as sensitivity analyses to the primary estimates or in addition to the primary estimates, but not included in the primary estimate of total monetized benefits. While no causal mechanism has been identified for chronic asthma and ozone exposure, there is suggestive epidemiological evidence.

    i. Two studies suggest a statistical association between ozone and new onset asthma for two specific groups: children who spend a lot of time exercising outdoors and non-smoking men. We seek SAB comment on our approach to quantifying new onset asthma in the sensitivity analyses.

    ii. Premature mortality associated with ozone is not currently separately included in the primary analysis because the epidemiological evidence is not consistent. We seek SAB comment on our approach to quantifying ozone mortality in the sensitivity analyses.

    iii. Does the Council agree that there is enough data to support a separate set of health impacts assessment for asthmatics? If so,

does the approach proposed by the Agency address the uncertainty in the literature?

Chapter 7: Ecological Effects

18. Does the Council support the plans described in chapter 7 for (a) qualitative characterization of the ecological effects of Clean Air Act-related air pollutants, (b) an expanded literature review, and (c) a quantitative, ecosystem-level case study of ecological service flow benefits? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

19. Initial plans described in chapter 7 reflect a preliminary EPA decision to base the ecological benefits case study on Waquoit Bay in Massachusetts. Does the Council support these plans? If the Council does not support these specific plans, are there alternative case study designs the Council recommends?

20. Does the Council support the plan for a feasibility analysis for a hedonic property study for valuing the effects of nitrogen deposition/eutrophication effects in the Chesapeake Bay region, with the idea that these results might complement the Waquoit Bay analysis?

Chapter 8: Economic Valuation

21. Does the Council support the plans described in chapter 8 for economic valuation of changes in outcomes between the scenarios? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

22. EPA's current analytic blueprint calls for an expert-judgment project on VSL determination that would produce a probability distribution over the range of possible VSL values for use in the 812 project. EPA is not sure how much priority to give to this project. A much simpler alternative would be for EPA to specify a plausible range of VSL values. One option would be to use a range bounded by $1 million (based roughly on the lower bound of the interquartile range from the Mrozek-Taylor meta-analysis) and $10 million (based roughly on the upper bound of the interquartile range of the Viscusi- Aldy meta-analysis. This range would match that reflected in EPA's sensitivity analysis of the alternative benefit estimate for the off-road diesel rulemaking. The range would then be characterized using a normal, half-cosine, uniform or triangular distribution over that range of VSL values. EPA would then ask this Committee to review this distribution. This approach could be done relatively quickly, based on the reviews and meta-analyses commissioned to date, and would allow a formal probability analysis to proceed, without suggesting that the Agency is trying to bring more precision to this issue than is warranted by the available science.

23. Pursuant to SAB Council advice from the review of the first draft analytical blueprint, EPA reviewed a number of meta-analyses –either completed or underway– developed to provide estimates for the value of statistical life (VSL) to be applied in the current study. EPA plans to consult with the Council (and coordinate this consultation with the EEAC) on how best to incorporate information from the Kochi et al (2002) meta-analysis, other published meta-analyses [Mrozek and Taylor and Viscusi and Aldy], and recent published research to develop estimates of VSL for use in this study. In addition, EPA plans to implement two particular adjustments to the core VSL values: discounting of lagged effects and longitudinal adjustment to reflect changes in aggregate income. Does the Council support these plans, including the specific plans for the adjustments described in chapter 8? If the Council does not support these plans, are there alternative data or methods the Council recommends?

24. For the 812 Report, EPA has decided to perform a cost-effectiveness analysis of the Clean Air Act provisions using quality-adjusted life years as the measure of effectiveness. This is the standard approach used in medicine and public health and this type of analysis has previously been recommended by the SAB. Moreover, the recent NAS Report (2002) on benefits analysis discussed how this method could be applied to the health gains from air pollution control.
    a. Do you agree that QALYs are the most appropriate measure of effectiveness for this type of analysis? Would you suggest any alternative measures to replace or supplement the QALY measure? (This question relates to effectiveness measures, not monetary benefit measures as used in benefit-cost analysis).
    b. OMB has suggested that EPA plan a workshop with clinicians, social scientists, decision analysts and economists to examine how the specific diseases and health effects in the 812 Report should be handled with respect to longevity impact and health-related preference. Participants would have knowledge of the relevant clinical conditions, the related health preference studies, and the stated-preference literature in economics. The recent RFF conference has laid the groundwork for this type of workshop. Is there a superior approach to making sure that the CEAQALY project is executed in a technically competent fashion and that the details of the work receive in-depth technical input in addition to the broad oversight provided by this Committee?
    c. Does the Council support the specific plans for QALY-based cost-effectiveness described in the current draft blueprint? If the Council does not support specific elements of these plans, are the alternative data, methods, or results presentation approaches which the Council recommends?

25. EPA plans to use updated unit values for a number of morbidity effects, as described in chapter 8. Of particular note, EPA plans to rely on a study by Dickie and Ulery (2002) to provide heretofore unavailable estimates of parental willingness to pay to avoid respiratory symptoms in their children. This study is

not yet published and has limitations concerning response rate and sample representativeness; however, EPA expects the study to be published prior to completion of the economic valuation phase of this analysis. Does the Council support the application of unit values from this study, contingent on its acceptance for publication in a peer-reviewed journal? If the Council does not support reliance on this study, are there other data or methods for valuation of respiratory symptoms in children which the Council recommends?

Chapter 9: Uncertainty Analysis

Does the Council support the plans described in chapter 9 for estimating and reporting uncertainty associated with the benefit and cost estimates developed for this study? If there are particular elements of these plans which the Council does not support, are there alternative data, models, or methods the Council recommends?

Does the Council support the plans described in chapter 9 for the pilot project to develop probability-based estimates for uncertainty in the compliance cost estimates? If the Council does not support this pilot project, or any particular aspect of its design, are there alternative approaches to quantifying uncertainty in cost estimates for this analysis which the Council recommends?

Does the Council support the plans described in chapter 9 for the pilot project to develop probability-based estimates for uncertainty in the emissions and air quality modeling estimates? If the Council does not support this pilot project, or any particular aspect of its design, are there alternative approaches to quantifying uncertainty in emissions and/or air quality concentration estimates for this analysis which the Council recommends?

Does the Council support the plans described in chapter 9 for the expert elicitation pilot project to develop a probability-based PM2.5 C-R function for premature mortality, including in particular the elicitation process design? If the Council does not support the expert elicitation pilot project, or any particular aspect of its design, are there alternative approaches the Council recommends for estimating PM-related mortality benefits for this analysis, including in particular a probabilistic distribution for the C-R function to reflect uncertainty in the overall C-R function and/or its components?

EPA plans to develop estimates of an independent mortality effect associated with ozone, as described in chapter 9. Does the Council support the use of the most recent literature on the relationship between short-term ozone exposure and daily death rates, specifically that portion of the literature describing models which control for potential confounding by PM2.5? Does the Council agree with the use of that literature as the basis for deriving quantified estimates of an independent mortality impact associated with ozone, especially in scenarios where short-term PM2.5 mortality estimates are used as the basis for quantifying PM mortality related benefits? Does the Council support the plans described in chapter 9 for the pilot project to use this literature to develop estimates of the ozone related premature mortality C-R function using the three alternative meta-analytic

approaches? If the Council does not support this pilot project, or any particular aspect of its design, are there alternative approaches to quantifying ozone-related premature mortality which the Council recommends?

EPA plans to work with the Council and the EEAC to develop revised guidance on appropriate VSL measures. We hope to include the Kochi et al (2002) meta-analysis, other recent meta-analysis, recent publications, and the 3 literature reviews sponsored by EPA.(a separate charge question pertaining to this element of EPA's VSL plan is presented below). In addition, EPA plans to conduct a follow-on meta-regression analysis of the existing VSL literature to provide insight into the systematic impacts of study design attributes, risk characteristics, and population attributes on the mean and variance of VSL. Does the Council support the plans described in chapter 9 for conducting this meta-regression analysis? If the Council does not support this analysis or any particular aspect of its design, are there alternative approaches which the Council recommends for quantifying the impact of study design attributes, risk characteristics, and population attributes on the mean and variance of VSL?

Chapter 10: Data Quality and Intermediate Data Products

32. Does the Council support the plans described in chapter 10 for evaluating the quality of data inputs and analytical outputs associated with this study, including the planned publication of intermediate data products and comparison of intermediate and final results with other data or estimates? If the Council does not support these plans, are there alternative approaches, intermediate data products, data or model comparisons, or other data quality criteria the Council reommends? Please consider EPA's Information Quality Guidelines in this regard.

Chapter 11: Results Aggregation and Reporting

33. Does the Council support the plans described in Chapter 11 for the aggregation and presentation of analytical results from this study? If the Council does not support these plans, are there alternative approaches, aggregation methods, results presentation techniques, or other tools the Council recommends?

Appendix D: Stratospheric Ozone Analysis

34. Does the Council support the plans describe in Appendix D for updating the estimated costs and benefits of Title VI programs? If the Council does not support these plans, are there alternative data, models, or methods the Council recommends?

Appendix E: Air Toxics Case Study

35. Does the Council support the plans described in Appendix E for the benzene case study, including the planned specific data, models, and methods, and the ways in

which these elements have been integrated? If the Council does not support these plans, are there alternative data, models, or methods the Council recommends?

36. A cessation lag for benzene-induced leukemia is difficult to estimate and model precisely due to data limitations, and EPA plans to incorporate a five-year cessation lag as an approximation based on available data on the latency period of leukemia and on the exposure lags used in risk models for the Pliofilm cohort (Crump, 1994 and Silver et al., 2002). Does the SAB support adoption of this assumed cessation lag? If the Council does not support the assumed five-year cessation lag, are there alternative lag structures or approaches the Council recommends?

Appendix H: Meta-analysis of VSL

37. Does the Council support including the Kochi et al. (2002) meta-analysis as part of a the larger data base of studies to derive an estimate for the value of avoided premature mortality attributable to air pollution? Are there additional data, models, or studies the Council recommends? Does the SAB think that EPA should include Kochi et al. 2003 if not accepted for publication in a peer reviewed journal by the time the final 812 report is completed?